TRAFFIC COMMISSION REPORT
July 22, 2010

Item VG

SAFETY OF COUNTDOWN PEDESTRIAN SIGNAL INDICATIONS

ISSUE:

Traffic Commission requested information on the safety of countdown pedestrian signals.

BACKGROUND

Burbank began using countdown pedestrian traffic signal indications over a year ago. We, like most communities in Southern California, are replacing old walking man / hand pedestrian signals with the new countdown variety. Anecdotal responses to the new signals have been very favorable, but we have no statistical information on the relative safety of the devices.

DISCUSSION:

A review of available literature found three studies of the countdown pedestrian signals. Studies were conducted in Buena Vista, San Francisco and San Jose for pedestrian compliance to the new indications. No studies were found that discuss driver behavior to the devices. All three of the studies indicated some increase in non-compliance of pedestrians when the countdown timing was displayed, and one study found an increase in running across the street. None of the studies showed a statistical decrease in pedestrian safety.

CONCLUSIONS

Recent studies show no statistical decrease in pedestrian safety with new countdown pedestrian signals.

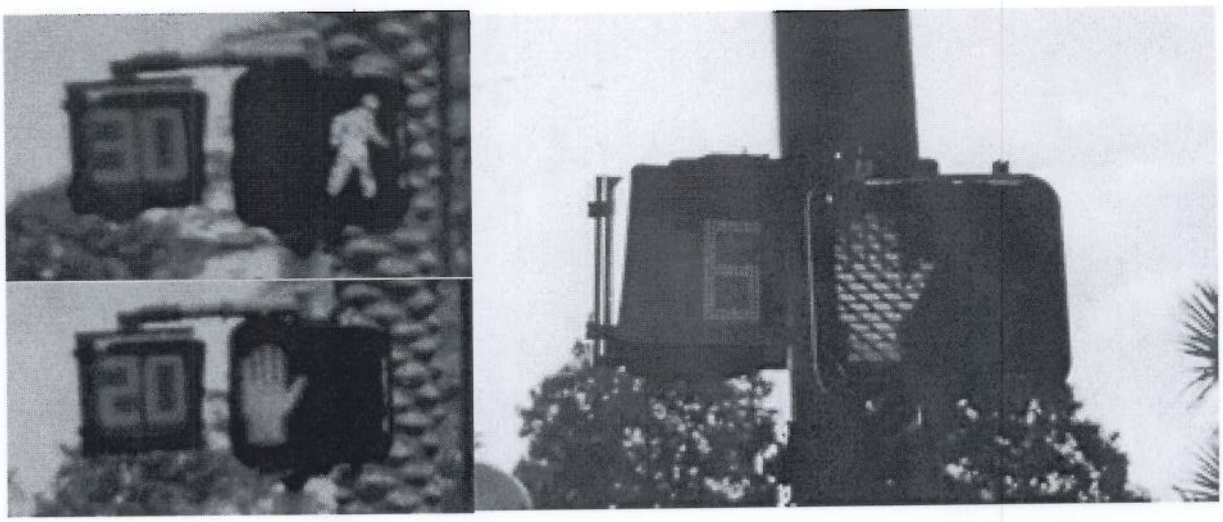
RECOMMENDATIONS:

Receive and File

ATTACHMENTS:

1. Effects of Countdown Pedestrian Signals in Lake Buena Vista
2. January 2008 Working Draft San Francisco Pedsafe Phase II (Excerpts)
3. Pedestrian Countdown Signals, an Experimental Evaluation, San Jose

The Effects of Pedestrian Countdown Signals in Lake Buena Vista



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November 2000

ABSTRACT

A countdown signal displays the number of seconds left until the steady Don't Walk phase appears and opposing traffic receives a green light. A pedestrian who has just arrived in the queuing area can use this information to decide whether to start crossing. A person who is in the crosswalk when the flashing Don't Walk interval appears can see the number of seconds remaining before the cross traffic gets a green light. This may reduce the likelihood that a person is still in the intersection when the light changes.

The objective of this study was to evaluate the effects of countdown signals at intersections in Lake Buena Vista, Florida. A "treatment" and "control" study design was used: countdown signals at two intersections were matched with three control intersections that were similar but did not have countdown signals. The countdown signals were evaluated according to three measures of effectiveness:

1. Pedestrian compliance with the Walk signal
2. Pedestrians who ran out of time
3. Pedestrians who started running when the flashing Don't Walk signal appeared

The countdown signals had the positive effect (compared to sites without countdown signals) of reducing the number of pedestrians who started running when the flashing Don't Walk signal appeared. They had the undesired effect of reducing compliance with the Walk signal. There was no effect on the number of persons who ran out of time while crossing.

It is recommended that countdown signals be tested at other locations. The use of countdown signals should be accompanied by public educational campaigns that explain what these devices are and how pedestrians can benefit from them.

Key words: Pedestrian, signal, countdown, crossing, compliance.

INTRODUCTION

Pedestrian signals display the messages Walk (or a walking person), flashing Don't Walk (or a flashing hand), and steady Don't Walk (or a steady hand) in conjunction with vehicle signals. The Walk signal indicates that pedestrians may cross the street in the direction of the signal. The flashing Don't Walk signal means that pedestrians should not start crossing, but pedestrians already in the street should have enough time to finish crossing. The steady Don't Walk phase means that pedestrians should not be in the street.

It is well-documented that many pedestrians do not understand the meaning of the pedestrian signal indications, particularly the flashing Don't Walk. In fact, Robertson *et al.* (1984) found that only about half of pedestrians understand the meaning of the flashing Don't Walk display. Many pedestrians expect to see the Walk signal for their entire crossing. Upon seeing the flashing Don't Walk, some pedestrians believe that they will not have enough time to reach the opposite side of the street. Others may return to the starting side, and a few may even stop in the middle of the street. (Zegeer, 1986)

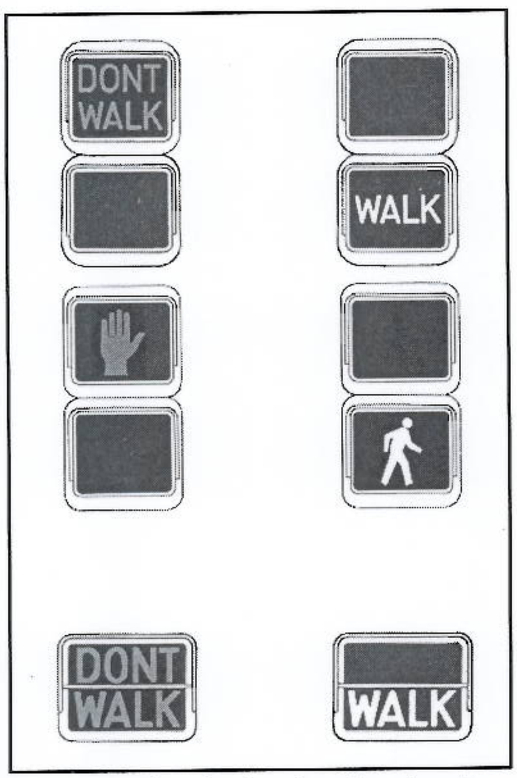

Figure 1. Standard pedestrian signal indications.

A pedestrian countdown signal contains a timer display that counts down and shows the number of seconds left to finish crossing the street. This device is intended to aid pedestrians in getting out of the street before they would be exposed to the danger of oncoming motor vehicles. A countdown signal can reassure a pedestrian who is in the crosswalk when the flashing Don't Walk phase appears that he or she still has time to finish crossing and does not need to panic, run to the opposite side, return to the starting side, or stop in the middle of the street. A countdown pedestrian signal is shown in Figure 2.

The use of a countdown pedestrian signal has several potential outcomes. The possible positive outcomes of the countdown signal (in terms of perhaps reducing crash risk) include:

- A pedestrian already in the street during the flashing Don't Walk (clearance interval) will see the countdown timer and take action such as walking faster if necessary to reach the other side of the street safely, before the timer counts down to zero (and cross traffic gets the green light).

- A pedestrian who arrives at the curb during the flashing Don't Walk and observes that the countdown shows only a few seconds may decide that there is not enough time to cross to the other side of the street and thus may wait until the beginning of the next Walk interval. The time available to cross a street is even more important when crossing wide streets, especially those with high traffic speed and volumes.

In the broader perspective, some traffic engineers may decide to use the countdown signal in the hope that it would not only improve pedestrian safety (*i.e.*, by reducing the number of pedestrians stranded in the street when cross traffic gets a green light), but also improve traffic flow on the cross street as a result.

The possible negative outcomes of the countdown signal (*i.e.*, increasing the risk of a pedestrian crash) include:

- A pedestrian arrives at the curb while the flashing Don't Walk is displayed along with the number of seconds remaining. The pedestrian mistakenly assumes that the time displayed on the countdown device is sufficient to cross the street. He or she begins crossing the street and is in the middle of the street when crossing traffic gets a green light. The pedestrian is at risk of being struck.

- A motorist stopped at an intersection on a red signal phase is waiting for the green light. The driver can clearly see the device counting down and uses it as a "starting gun" to step on the accelerator as soon as the countdown displays zero seconds, even before he or she gets the green light. A pedestrian who is still in the process of crossing the street may be struck by this motorist.

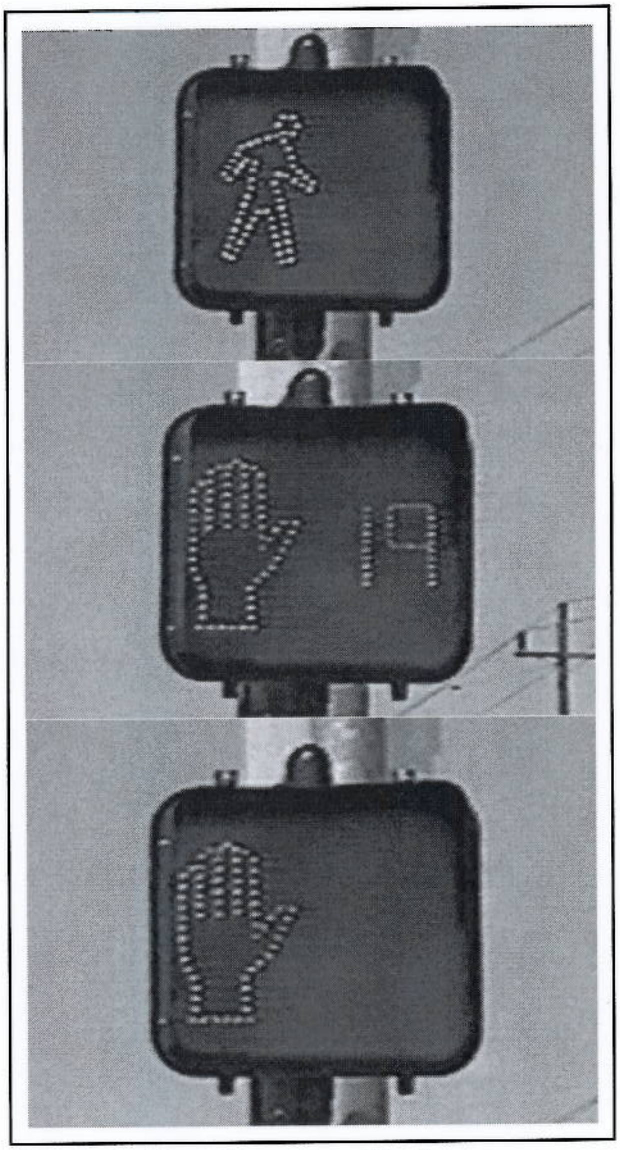

Figure 2. Countdown signal in Sacramento County, California.

(Top)	No time display appears during the Walk interval.
(Middle)	The timer counts down through the flashing Don't Walk interval.
(Bottom)	After the timer reaches zero, the time display disappears.

Countdown signals were installed at several intersections in Sacramento County, California, in 1997 and 1998. Huang and Zegeer (1999) found that those countdown signals reduced pedestrian compliance with the Walk phase. Another adverse effect was that the countdowns increased the number of people who finished crossing after the steady Don't Walk display appeared. The countdowns did not affect whether pedestrians ran or hesitated while crossing.

This report evaluates countdown signals at two intersections in Lake Buena Vista, Florida. This study focused on determining the positive and negative effects of these devices on pedestrian behavior.

DATA COLLECTION

A treatment-and-control study design was used. Data were collected at two signalized intersections (one crosswalk at each) with countdown pedestrian signals (the "treatment" sites). Each intersection was matched with one or two nearby "control" intersections which had conventional pedestrian signals (Table 1). Data collection took place on various days between May and November 1999, during daylight hours and under dry conditions.

Table 1. Intersections where data were collected.

INTERSECTION	T/C	HOURS OF DATA COLLECTION	NUMBER OF PEDESTRIANS
State Route 535 at Hotel Plaza Blvd., north crossing	T	6 h 00 min	232
County Route 535 at Vinings Way Blvd., north crossing	C	6 h 00 min	32
State Route 535 at Palm Parkway, north crossing	C	16 h 00 min	250
Buena Vista Drive at entrance to Team Disney, east crossing	T	4 h 00 min	136
Buena Vista Drive at entrance to Disney Casting Center, east crossing	C	3 h 45 min	26

T = Treatment site, with a countdown signal
C = Control site

A video camera was used to record data at all locations. The video camera was placed on a tripod and set up on the sidewalk along the side street, approximately 23 m (75 ft) upstream from the intersecting main road. The camera faced in the same direction as traffic on that half of the side street. This position enabled the camera to record, on videotape, pedestrians in the crosswalk as they were crossing the main road, and those waiting in the queuing areas on either side of the main road. The camera also recorded signal phases for parallel traffic on the side street and pedestrian phases for pedestrians crossing the main road.

The countdown signals were evaluated according to three measures of effectiveness (MOE's):

1. Pedestrian compliance with the Walk signal
2. Pedestrians who ran out of time when crossing the street
3. Pedestrians who started running when the flashing Don't Walk signal appeared

It should be noted that the sample sizes vary for each MOE, because: (1) some MOE's pertain to only a subset of the total number of pedestrians; and (2) some pedestrians were not clearly videotaped.

SITE DESCRIPTIONS

At all of the intersections used in this study, pedestrian signals with conventional push buttons control the crosswalks of interest. The Walk signal will not appear unless the button is pushed. Descriptions of the two treatment and three control sites are given below.

State Route 535 at Hotel Plaza Boulevard (existing countdown pedestrian signal)

State Route 535 is a bustling north-south commercial strip with many hotels, restaurants, and souvenir shops (Figures 3 and 4). The east leg of Hotel Plaza Boulevard is the entrance to a shopping plaza. The west leg of Hotel Plaza Boulevard is one of the entrances to Walt Disney World™. State Route 535 has three lanes of through traffic and a right-turn lane in each direction. There is one left-turn lane for southbound traffic and two left-turn lanes for northbound traffic. Northbound and southbound traffic are separated by a raised grass median. The ADT is 68,300 vehicles per day and the speed limit is 64 km / h (40 mi / h).

The northside crosswalk is equipped with a countdown signal. It starts at 37 seconds, when the Walk first appears. At 25 seconds, the flashing Don't Walk appears. At 0 seconds, the steady Don't Walk appears and the timer display disappears.

There was steady pedestrian activity during the data collection periods. Most pedestrians crossed in groups. Because of heavy traffic along State Route 535, someone in most groups pushed the button, and people usually waited for the Walk phase.

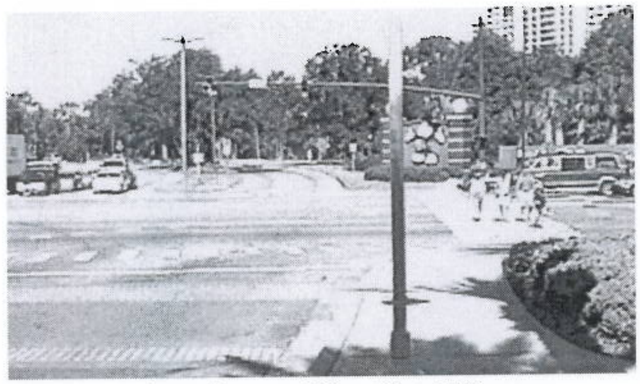

Figure 3. State Route 535 at Hotel Plaza Boulevard (countdown signal site).

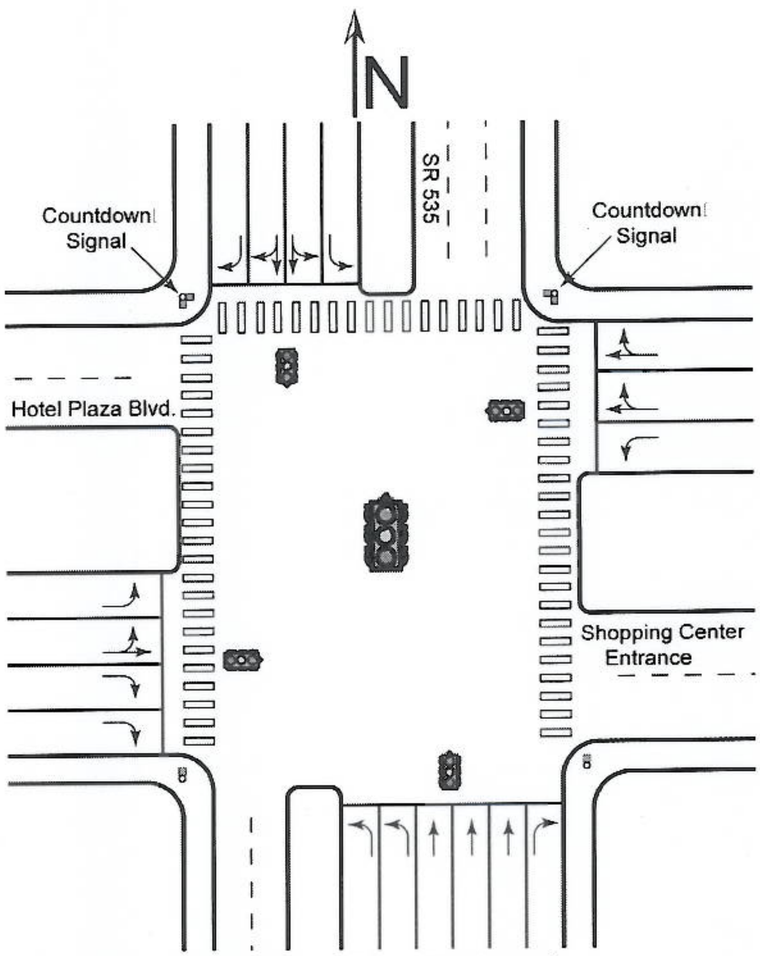

Figure 4. SR 535 at Hotel Plaza Boulevard.

County Route 535 at Vinings Way Drive (control site #1 for State Route 535 at Hotel Plaza Boulevard)

This T-intersection is two traffic lights, about 0.8 km (0.5 mile) north of its matching treatment site (State Route 535 at Hotel Plaza Boulevard) (Figure 5). The east leg is the entrance to a shopping plaza. County Route 535 has two lanes of through traffic and a left-turn lane in each direction, and a raised grass median. The ADT is 47,200 vehicles per day and the speed limit is 64 km / h (40 mi / h). Compared to State Route 535 at Hotel Plaza Blvd., pedestrian activity was more sporadic here. The area north of this intersection is largely undeveloped.

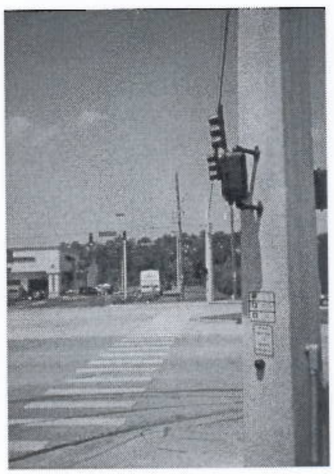

Figure 5. County Route 535 at Vinings Way (control site #1).

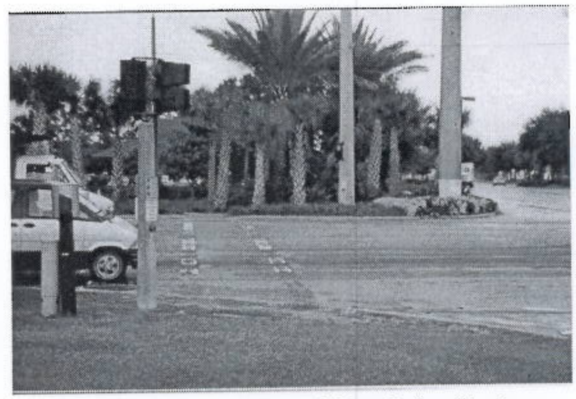

Figure 6. State Route 535 at Palm Parkway (control site #2).

State Route 535 at Palm Parkway (control site #2 for State Route 535 at Hotel Plaza Boulevard)

Because of low pedestrian activity at Vinings Way Drive, a second control site for Hotel Plaza Boulevard was added to the study. This site is about halfway in-between Hotel Plaza Boulevard and Vinings Way Drive. State Route 535 approaches this intersection from the south and turns to the west. It has two lanes of through traffic and a left-turn lane in each direction, and a raised grass median (Figure 6). The ADT is 47,200 vehicles per day and the speed limit is 64 km / h (40 mi / h). To the north of the intersection, the road is known as County Route 535 and has a similar cross-section as State Route 535 to the south. Palm Parkway approaches from the east. It has two lanes of through traffic in each direction, left- and right-turn lanes for westbound traffic, and a raised median. There are hotels, restaurants, and souvenir shops here. More pedestrian activity was observed here than at County Route 535 and Vinings Way Drive.

<u>Buena Vista Drive at entrance to Team Disney, east leg</u> (existing countdown pedestrian signal)

Buena Vista Drive is an east-west roadway with a raised grass median (Figures 7 and 8). There are three through lanes and a left-turn lane in each direction. The ADT is 30,500 vehicles per day and the speed limit is 56 km / h (35 mi / h). The north side of Buena Vista Drive is occupied by Downtown Disney, which is a shopping, restaurant, and entertainment complex. Team Disney, which houses Walt Disney Company offices, is on the south side.

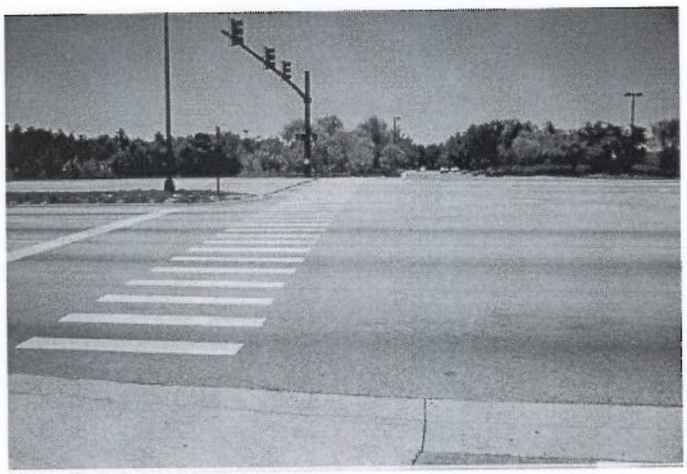

Figure 7. Buena Vista Drive at Team Disney (countdown signal site).

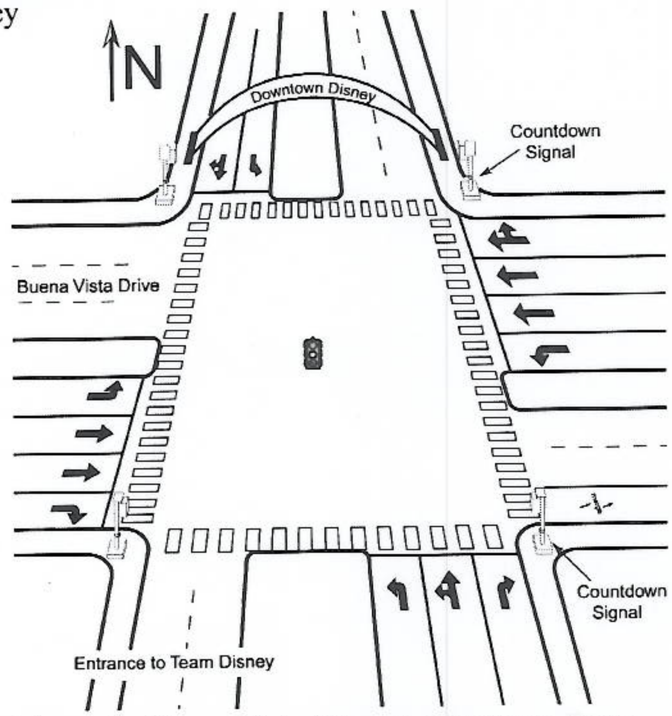

Figure 8. Buena Vista Drive at entrance to Team Disney.

Buena Vista Drive at entrance to Disney Casting Center, east leg (control site for Buena Vista Drive / Team Disney)

This location is one traffic light (about 1/4 mile) east of its corresponding treatment site (Buena Vista Drive at entrance to Team Disney). Buena Vista Drive is an east-west roadway with a raised grass median (Figure 9). There are three through lanes and a left-turn lane in each direction. The ADT is 30,500 vehicles per day and the speed limit is 56 km / h (35 mi / h). Downtown Disney is on the north side of Buena Vista Drive. The Disney Casting Center serves as the Walt Disney World™ employment office, and is on the south side.

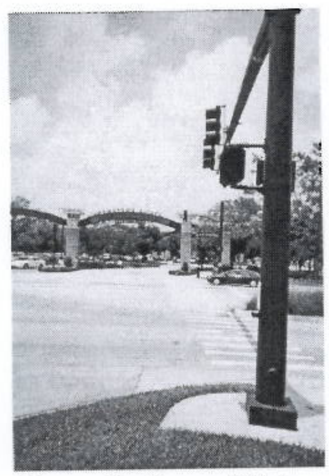

Figure 9. Buena Vista Drive at Disney Casting Center (control site).

RESULTS

For analysis purposes, the two countdown signal sites were combined and the three control sites were combined.

Pedestrian Compliance with the Walk Signal

A pedestrian complied with the Walk signal if he or she started crossing during the Walk interval. Pedestrians who crossed during the flashing or steady Don't Walk for any reason (such as impatience, arriving late, or not pushing the button and not getting a Walk) were not in compliance with the Walk signal.

With countdown pedestrian signals, pedestrians who arrive at the curb just as the flashing

Don't Walk appears will see that they still have as much as 20-25 seconds left to cross. Some may decide to "go for it" instead of pushing the button and waiting for the next Walk interval. Thus, it was hypothesized that countdown signals might have the *undesirable* effect of reducing compliance with the Walk signal.

The chi-square statistic was used to compare the levels of compliance at the countdown signal locations and the control sites. Figure 10 and Table 2 show that pedestrians were less

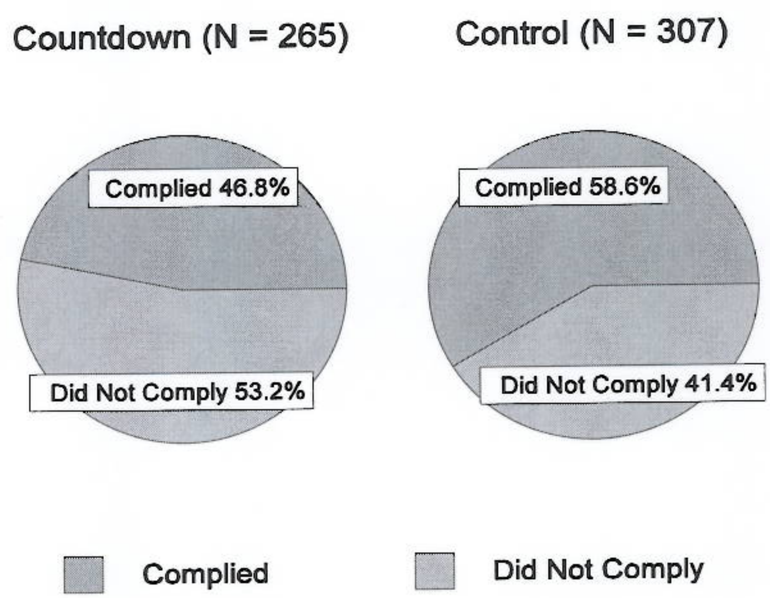

Figure 10. Pedestrians who complied with the Walk signal.

likely to comply at the countdown signal locations than at the control sites. This difference was significant at the 0.005 level. The findings support the hypothesis.

Table 2. Pedestrians Who Complied with the Walk Phase

	Countdown	Control
Complied	124 (46.8%)	180 (58.6%)
Did Not Comply	141 (53.2%)	127 (41.4%)

chi-square statistic = 8.006302
p-value, with one degree of freedom = 0.004662 SIGNIFICANT

Pedestrians Who Ran Out of Time

Pedestrians who start crossing on a Walk or flashing Don't Walk signal and who are still in the crosswalk when the steady Don't Walk signal is displayed and parallel traffic has the red signal have one to two seconds of an all-red interval before cross traffic gets the green signal. For the purposes of this analysis, such pedestrians were considered to have run out of time. It was hypothesized that countdown signals might have the *desirable* result of fewer pedestrians remaining in the intersection after the steady Don't Walk appears, since they will know how much time they have and will presumably attempt to finish crossing before "time runs out."

Some people started and finished on a steady Don't Walk either because: (1) no one pushed the button and the Walk signal never came on, or (2) they started and finished while opposing traffic had the green. These people were not included in this analysis.

The chi-square statistic was used to compare the number of pedestrians who finished crossing after time ran out at the countdown signal locations and the corresponding control locations. Figure 11 and Table 3 show the number of pedestrians (total of all three study locations) who ran out of time (*i.e.*, started crossing on a Walk or flashing Don't Walk and finished crossing during the steady Don't Walk). A slightly smaller percentage of people ran out of time at the control sites than at the countdown sites, but the difference was not statistically significant.

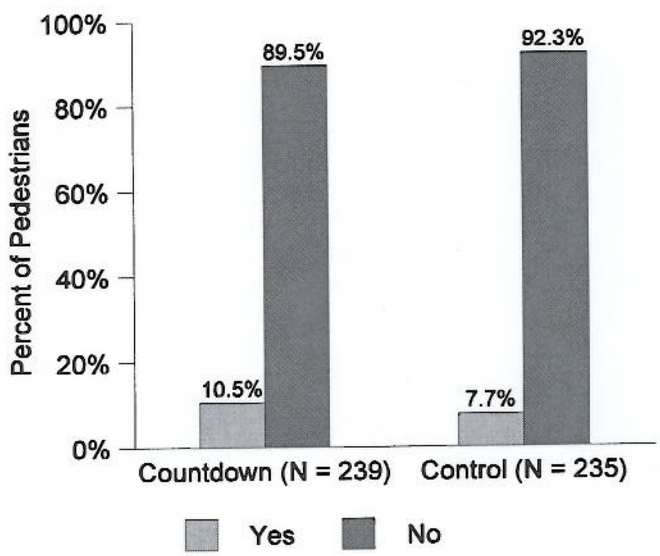

Figure 11. Pedestrians who ran out of time.

Table 3. Pedestrians Who Were Crossing When the Steady Don't Walk Was Displayed

	Countdown	Control
Yes	25 (10.5%)	18 (7.7%)
No	214 (89.5%)	217 (92.3%)

chi-square statistic = 1.126717
p-value, with one degree of freedom = 0.288477 NOT SIGNIFICANT

Pedestrians Who Started Running When the Flashing Don't Walk Display Appeared

It was thought that the effects of countdown signals on pedestrian crossing behavior are likely to be mixed. On the one hand, the timer display may reassure crossing pedestrians that they still have time to finish crossing, even when the flashing Don't Walk is being displayed. On the other hand, more pedestrians may decide to "run for it" when they arrive on flashing Don't Walk if they see how many seconds are left. In this study, it was hypothesized that countdown signals would have the *desirable* effect of *less* running when the flashing Don't Walk display first appears.

About three percent of those crossing at the treatment sites and ten percent of those crossing at the control sites started running when the flashing Don't Walk signal appeared (Figure 12 and Table 4). This difference was significant, with a p-value of 0.011. This finding suggests that pedestrians are paying attention to the countdown timer display and are not being confused as to the meaning of the countdown signal.

Table 4. Pedestrians Who Started Running When the Flashing Don't Walk Appeared

	Treatment	Control
Yes	10 (3.4%)	25 (10.4%)
No	203 (96.6%)	221 (89.6%)

chi-square statistic = 6.405311
p-value, with one degree of freedom = 0.011378 SIGNIFICANT

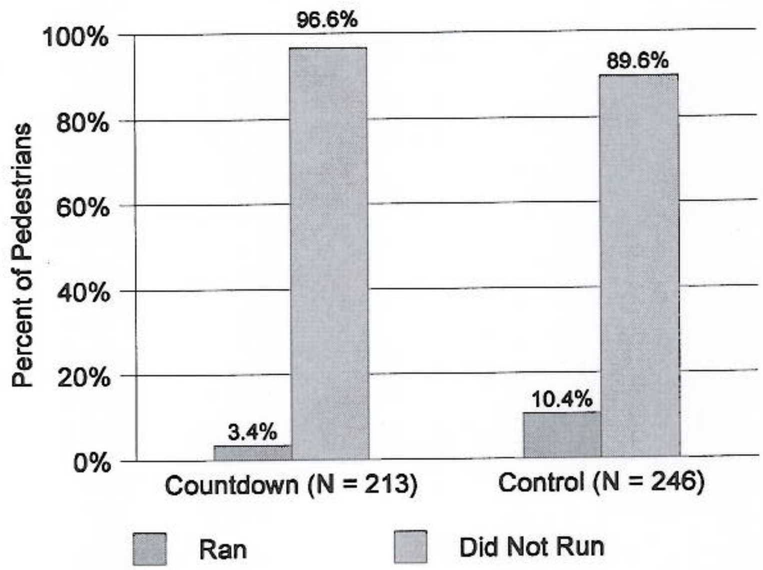

Figure 12. Pedestrians who started running when the flashing Don't Walk display appeared.

CONCLUSIONS AND RECOMMENDATIONS

This study involved the before-and-after evaluation of countdown signals on pedestrian behavior. Two crosswalks at two intersections in Lake Buena Vista, Florida, were used for test purposes. Three nearby crosswalks without countdown signals (*i.e.*, the control sites) were used for comparison purposes. The key findings and authors' discussion are given below.

1. The countdown signals had both positive and negative effects on pedestrian behavior at the treatment sites, compared to the matched control sites.

Table 5 summarizes the effects of countdown signals by each MOE. For example, the countdown signals had a desirable effect on pedestrian running (*i.e.*, less running) when the flashing Don't Walk signal appeared. Because relatively few people arrived at the curb during the flashing Don't Walk interval, no conclusions can be drawn as to whether they were more or less likely to push the button and wait for the next Walk signal.

Table 5. The effects of countdown signals by MOE.

MOE	EFFECT
COMPLIANCE WITH WALK SIGNAL	U
RAN OUT OF TIME	N
STARTED RUNNING WHEN FLASHING DON'T WALK SIGNAL APPEARED	•

• Had desirable effect, significant at the 0.10 level.
U Had undesirable effect, significant at the 0.10 level.
N No effect.

A potential drawback of a countdown signal is that some pedestrians who would otherwise wait for the next Walk signal may be encouraged to start crossing on the flashing Don't Walk, with insufficient crossing time. This, of course, can result in more persons being stranded in the street when cross-traffic gets the green light. Although the countdown signals were found to reduce compliance with the Walk signal (an undesirable effect), the countdowns did not appear to have had an effect on the number of pedestrians who ran out of time. This clearly may be the result of some pedestrians leaving during the flashing Don't Walk but walking fast to complete their crossing before the steady Don't Walk is displayed.

2. Based on these results and those of other studies, countdown signals are *not* recommended for use at standard intersections in Florida.

Countdown signals may result in more pedestrian signal violations among some age groups. For example, teenage and young adult males (such as near high schools and universities) may try to "beat the light" after seeing that they still have several seconds to cross. Countdowns may be more promising at intersections that are frequented by an older adult population, by virtue of the added information about the time available for crossing.

3. The countdown pedestrian signals should be tested at other signalized intersections.

The present study was a behavioral evaluation of countdown pedestrian signals using two treatment sites and three control sites. Ideally, data would have been collected using a before-and-after approach, at a larger number of locations. Countdown signals should be tested in other cities, especially those with multiple countdown signal installations. With a before-and-after study, it is more likely that any effects on pedestrian and motorist behavior are in fact the result of the treatment alone, and not from differences between sites. However, a before-and-after study requires that the data collection be coordinated with local agencies' installation schedules. This was not possible within the time frame of this study, so a treatment-and-control study was conducted as the next best option. Of course, conducting a crash-based analysis of a countdown signal would require hundreds or thousands of test sites in order to have an adequate sample of pedestrian crashes.

4. Instead of pedestrian countdown signals, there may be more effective alternatives to improve pedestrian safety and service at signalized intersections.

A number of alternative devices and treatments are available to the traffic engineer to improve conditions for pedestrians at signalized intersections. These may be more effective alternatives than pedestrian countdown signals in achieving more desirable pedestrian and / or motorist behavior.

Pedestrian signalization alternatives

- **Longer Walk and clearance intervals:**
  At wide intersections, pedestrian crossing times often dictate green splits and cycle lengths. As a result, *minimum* Walk and flashing Don't Walk times are too often used. The *Manual on Uniform Traffic Control Devices* recommends a minimum Walk interval of 4 to 7 seconds (MUTCD, 1988). With such a short interval, pedestrians may only get one or two lanes across the street before the flashing Don't Walk appears and they may get confused or even panic (because they do not understand the meaning of the flashing Don't Walk). It is desirable to provide a longer Walk interval whenever practical. Also, the timing of clearance (*i.e.*, flashing Don't Walk) intervals to assume slower walking speeds (*e.g.*, 0.9 or 1.1 m / sec (3 or 3.5 ft / sec) instead of 1.2 m / sec (4 ft / sec)) may also be appropriate, particularly at locations with older pedestrians which cross the street regularly.

- **Exclusive pedestrian signal phasing at downtown intersections:**
  Most pedestrian signals use standard (or concurrent) timing, in which the Walk signal is displayed at the same time with the green light for parallel traffic. Under such a timing scheme, right- and left-turning motor vehicles may conflict with pedestrians crossing on the Walk signal (and many motorists will not yield to pedestrians when making turns at such intersections).

  Two alternatives are exclusive timing and scramble (or Barnes dance) timing. With exclusive timing, all vehicular traffic is stopped and pedestrians are allowed to cross in any crosswalk: the Walk interval is displayed for all crosswalks at the same time, while all motorists have a red traffic signal. Exclusive timing has been associated with approximately a fifty percent reduction in motor vehicle - pedestrian crashes as compared to standard timing (Zegeer *et al.*, 1985). With scramble timing, all vehicular traffic is stopped and pedestrians are allowed to cross in any crosswalk or diagonally across the intersection (Figure 13). These exclusive timing schemes are most appropriate in downtown signalized intersections with high pedestrian volumes (1,200 or more per day), and relatively low vehicle speeds and volumes. Such timing schemes will typically increase vehicle and pedestrian delay, since longer signal cycles are required, and it may

Figure 13. With scramble timing, pedestrians are allowed to cross in any direction, including diagonally.

be difficult to synchronize adjacent signals. Exclusive timing plans are generally impractical outside of downtown areas.

Reducing pedestrian crashes involving through vehicles

- **Refuge Islands:**
  Refuge islands are areas within an intersection or between lanes of traffic where pedestrians may safely wait if they are unable to cross the entire street within the allotted time. A refuge island at a signalized intersection can provide a place for slower pedestrians to safely stop and wait for the next cycle to finish crossing.

- **Medians:**
  Streets with raised medians experienced lower pedestrian crash rates compared to streets with painted two-way left turn lanes or undivided streets (Bowman and Vecellio, 1994).

  A refuge island or median island should be a minimum of 1.2 m (4 ft) (and preferably 1.8 m, or 6 ft) wide, and at least 3.7 m (12 ft) long or the width of the crosswalk, whichever is greater. Cut-through ramps at pavement level or curb ramps are needed to accommodate wheelchair users. More information about medians and refuge island design can be found in the Institute of Transportation Engineers' *Design and Safety of Pedestrian Facilities* (1998).

- **Automated pedestrian detection:**
  Infrared, microwave, or video detection devices can be installed to automatically detect pedestrians waiting at the curb and activate the pedestrian phases (Figure 14). The devices can be set up so that if the pedestrian starts crossing before the WALK phase, the "call" for the pedestrian phase will be canceled, thereby reducing delay to cross traffic.

These devices can also detect persons in the crosswalk and extend the clearance interval if necessary so that pedestrians will have time to finish crossing.

Automated pedestrian detectors were evaluated in Los Angeles, CA (infrared and microwave), Phoenix, AZ (microwave), and Rochester, NY (microwave) (Hughes *et al.*, 1999). The results indicated that the use of automated detection devices in conjunction with the standard pedestrian push-button resulted in a significant reduction in vehicle-pedestrian conflicts as well as a reduction in the number of pedestrians beginning to cross during the steady Don't Walk phase. Detailed field testing of the microwave equipment

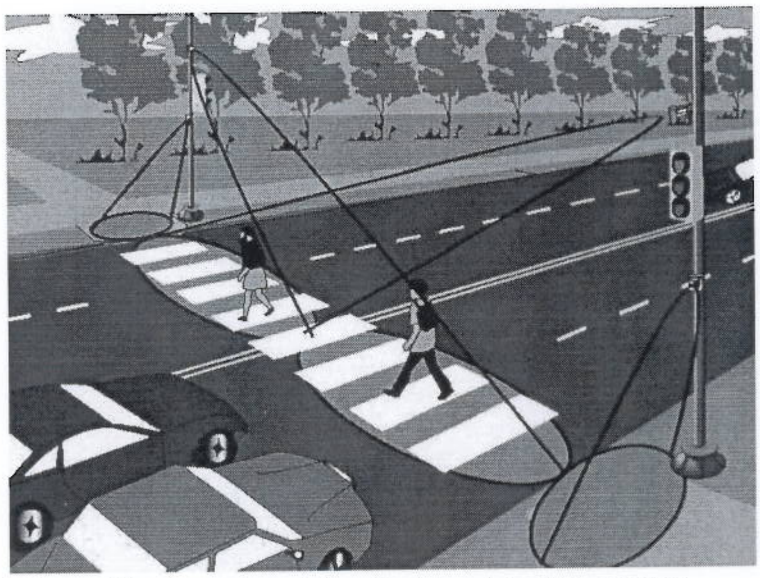

Figure 14. An automated pedestrian detection system.

in Phoenix revealed that fine tuning of the detection zone is still needed to reduce some false calls and missed calls (Hughes *et al.*, 1999).

Education and enforcement

Education and enforcement can help improve conditions for pedestrians. Table 2 and Figure 10 show that 47 percent of pedestrians at the countdown sites, and 58 percent of those at the control sites, complied with the Walk phase. In other words, 53 and 42 percent, respectively, did not comply. Some of those who started crossing on a flashing Don't Walk were still in the street when the countdown timer reached zero. This finding highlights the need to educate pedestrians as to what the signals mean and when it is appropriate to cross the street. For instance, an informational sign could explain what pedestrians should do during the Walk, flashing Don't Walk, and steady Don't Walk signal intervals (Figure 15).

Figure 15. A sign that explains the meaning of the pedestrian signal displays.

Driver education programs should deal effectively with driver responsibility to yield to pedestrians when turning at intersections and other situations where motorists should yield the right-of-way to pedestrians, driving slowly in pedestrian areas, etc. Better enforcement of driver compliance to traffic signals (perhaps using red light cameras) may also be effective in improving pedestrian safety at signalized intersections.

ACKNOWLEDGMENTS

This study was conducted as part of a research project funded by the Florida Department of Transportation. Theo Petritsch was the Contracting Officer's Technical Representative for Florida DOT. The authors gratefully acknowledge the information provided by Stokes Wallace (Control Specialists, Inc. -- the countdown signal distributor). Charles Hamlett, L. Travis Huey, and Bradley Keadey (all University of North Carolina Highway Safety Research Center) assisted with data collection. Thomas Meadows (University of North Carolina Highway Safety Research Center) drew the intersection diagrams. Eric Rodgman and J. Richard Stewart (both University of North Carolina Highway Safety Research Center) provided computer and statistical expertise, respectively.

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January 11, 2008 Working Draft San Francisco PedSafe Phase II Final Report and Executive Summary

1.9.2. Pedestrian Countdown Signals

San Francisco has been a national leader in the use of pedestrian countdown signals, converting virtually all of the pedestrian signals citywide (over 800 intersections) to the countdown version This was completed outside of the FHWA PedSafe project, and the results of the conversion were reported separately and in greater detail.[5]

During the 14-intersection pilot installation, there were statistically significant improvements in pedestrian behavior and attitudes. The number of pedestrians who finished crossing during the red phase decreased from 14% to 9%. The proportion of pedestrians who ran or aborted their crossing decreased from 13% to 8%. The proportion of pedestrians who reported the pedestrian signals to be "very helpful" increased from 34% to 76%.

At 579 intersections converted from conventional to countdown pedestrian signals, the number of pedestrian injury collisions decreased by 22%. During the same period, at 204 other intersections without countdown signals, the decline was only 2%. The proportion of all traffic collisions attributed to running a red light decreased from 45% to 34%. While there were numerous factors affecting the decline in the number of drivers running red lights, it is likely that the countdown devices played a major role by providing warning to drivers approaching a "stale green" (a green light about to change).

4.3.2. Pedestrian Countdown Signals

San Francisco has been a national leader in the use of pedestrian countdown signals, converting virtually all of the pedestrian signals citywide (over 800 intersections) to the countdown version This was completed outside of the FHWA PedSafe project, and the results of the conversion were reported separately and in greater detail[15] Pedestrian countdown signals have been proposed as the standard form of the device for revisions to the *Manual on Uniform Traffic Control Devices* expected in 2009.

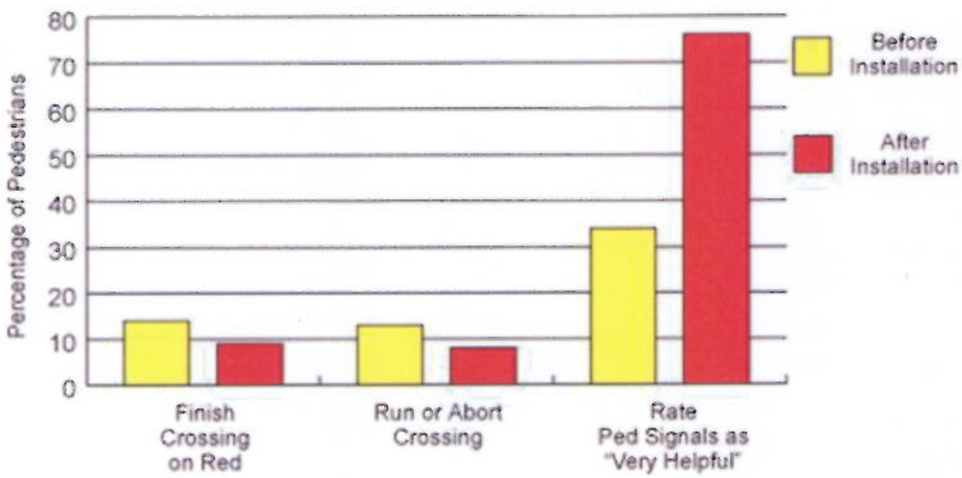
Pedestrian Countdown Signal Pilot Project: Pedestrian Injury Decline
During the 14-intersection pilot project, pedestrian injuries decreased by about half at intersections equipped with countdown signals. However, this decline was not statistically significantly greater than the decline at control intersections not receiving countdown signals. This likely reflects some regression to the mean.

In general, when countdown signals were installed, both during the pilot installation phase, and during the later citywide installation, signal timing was also changed. Previously, the San Francisco practice was to carry the flashing Red Hand (flashing Don't Walk) pedestrian phase through the yellow traffic indication phase. The solid Red Hand (solid Don't Walk) started concurrently with the start of the red traffic indication. With the countdown signal installation, this changed so that the solid Red Hand began at the beginning of the yellow phase, more consistent with the signal practice of other cities in Northern California.

Pedestrian Countdown Signal Impacts On Pedestrian Behavior and Attitudes
Pedestrian countdown signals were responsible for statistically significant improvements in pedestrian behavior and attitudes. Pedestrians finishing crossing in the red phase decreased from 14% to 9%. The proportion of pedestrians running or aborting their crossing decreased from 13% to 8%. The proportion of pedestrians finding the pedestrian signals "very helpful" increased from 34% to 76%. (See Figure 4.3-3.)

Pedestrian Countdown Signal: Citywide Conversion Impacts
At 579 intersections converted from conventional to countdown pedestrian signals, the number of pedestrian injury collisions decreased by 22%. During the same period, at 204 other signalized intersections without countdown signals, the decline was only 2%. The proportion of all traffic collisions attributed to red light running decreased from 45% to 34%. While there were numerous factors affecting the decline in the number of drivers running red lights, it is likely that the countdown devices played a major role by providing warning to drivers approaching a green light about to change.

Table 4.3-3
Pedestrian Countdown Signals Pilot Project: Impacts on Behavior and Attitudes

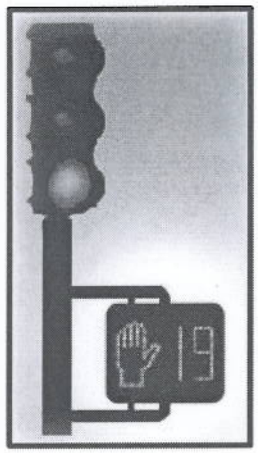


on Collision

Impacts
At 579 intersections converted from conventional to countdown pedestrian signals, the number of pedestrian injury collisions decreased by 22%. During the same period, at 204 other signalized intersections without countdown signals, the decline was only 2%. The proportion of all traffic collisions attributed to red light running decreased from 45% to 34%. While there were numerous factors affecting the decline in the number of drivers running red lights, it is likely that the countdown devices played a major role by providing warning to drivers approaching a green light about to change.

Pedestrian Countdown Signals: An Experimental Evaluation

Volume 1



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BACKGROUND AND INTRODUCTION

The countdown signal displays flashing numbers that count down the time remaining until the end of the flashing "DON'T WALK" (FDW) interval. The countdown display, which can start at the onset of either the WALK or the FDW display, reaches zero and blanks out at the onset of the steady "DON'T WALK" (DW) display. When the countdown starts at the beginning of the FDW, the duration of the countdown is approximately equal to the pedestrian clearance interval for the crosswalk (the duration may vary according to local signal timing practice). This issue is discussed later in this report.

The first installation of countdown signals in California occurred in Sacramento County in 1998. Since that time, many cities have installed countdown signals. The City of San Jose made a request to the California Traffic Control Devices Committee (CTCDC) to install these signals on an experimental basis at five intersections to study their effectiveness. In November 2000, the request was granted to install the signals at five intersections for testing.

For the San Jose study, the countdown accompanying the FDW display (as illustrated below) was tested.


WALK

FDW


DW

According to Huang and Zegeer (1) the principal motivation for the pedestrian countdown signal is to aid pedestrians in getting out of the street before they would be exposed to oncoming motor vehicles. However, during deliberation at the CTCDC meeting in June 2001 to develop standards for the various agencies testing the devices in California, several issues were raised that needed to be addressed regarding the operation of the countdown signals. The following questions arose:

- Could the public incorrectly interpret the countdown display to mean that it is permitted to leave the curb as long as it is possible to complete the crossing before the countdown reaches zero?
- Would erratic behavior of pedestrians, such as running, hesitating or turning around in the crosswalk increase?
- Would the incidence of motorists entering the intersection on yellow or red increase?

The above issues were addressed in the San Jose study and are discussed in this report. In addition, it was considered important to gain some understanding of other related issues, such as pedestrians' ability to judge how long it would take to clear a crosswalk. To gain perspective on safety issues, studies of crash history and pedestrian-vehicle conflicts at the study sites were undertaken.

The objective of this report is to present the results of the study of the performance of the countdown signals in the City of San Jose, including relevant data gathered at other intersections in the city, conclusions and recommendations.

The report is presented in two volumes. Volume 1 contains an overview of existing studies and other relevant literature, the study approach, relevant information on the study sites, results of the study of pedestrian behavior, motorist behavior, traffic conflicts and crash analysis. An overview of existing practices for pedestrian signal timing in California, together with information on incorporating countdown signals in timing procedures, is provided. A summary of the major conclusions as well as a discussion and recommendations follow. Volume 2 consists of appendices that contain more detailed reports of data collection and analysis.

REVIEW OF EXISTING DOCUMENTATION

The California Vehicle Code 2002 Edition (2) states the lawful actions of pedestrians when confronted pedestrian signal displays as:

> "(a) 'Walk' or Approved 'Walking Person' symbol. A pedestrian facing the signal may proceed across the roadway in the direction of the signal, but shall yield the right-of-way to vehicles lawfully within the intersection at the time that signal is first shown.
>
> (b) Flashing or steady 'DONT WALK' or 'WAIT' or approved 'Upraised Hand' symbol. No pedestrian shall start to cross the roadway in the direction of the signal, but any pedestrian who has partially completed crossing shall proceed to a sidewalk or safety zone or otherwise leave the roadway while the 'WAIT' or 'DONT WALK' or approved 'Upraised Hand' symbol is showing."

The code further states that it "..shall be unlawful for any pedestrian to fail to obey any sign or signal erected or maintained to indicate or carry out the provisions of this code.."

That conventional FDW signals are misunderstood by a significant percentage of pedestrians is a phenomenon that does not seem to be in dispute. Literature on Canadian crosswalk research prepared for the U.S. Department of Transportation's Federal Highway Administration (3) reports that 80 percent of pedestrians surveyed inaccurately interpreted the pedestrian clearance phase of the FDW display. Robertson, et. al. found that about half of pedestrians understood the FDW display (4). Surveys in Hampton, Virginia, indicated that 25 percent of pedestrians do not understand the meaning of FDW signal heads (5).

The results of other studies vary, but the message is the same: many pedestrians are inappropriately interpreting the message sent by FDW signals. There also seems to be general agreement regarding the results of the aforementioned misinterpretations. Some people perceive a flashing hand or a FDW message to mean that they can enter the intersection because the steady hand or DW message is not yet displayed (1). Others, particularly the elderly, see the FDW command and return to their origin curb (6).

The findings on the effectiveness of countdown pedestrian signal heads are less conclusive. The assumption underlying this variety of pedestrian signal is that pedestrians that know how much time they have left to cross are better informed and, as a result, make better decisions when crossing the street. Some research supports this theory; some refutes it.

For instance, a study by the Minnesota Department of Transportation (7) found that crosswalk signal modifications that included pedestrian countdown signals increased "successful crossings" from 67 percent to 75 percent, and improvements for the elderly were even more dramatic. It is noteworthy, though, that a "successful crossing" was defined as a crossing that began during the WALK or FDW phase of the pedestrian signal and ended before the steady DW indication. The incidence of pedestrians leaving the curb during the WALK indication and finishing during the WALK or FDW indication increased less dramatically, from 55 percent before the installation to 62 percent after. Furthermore, the incidence of pedestrians starting on FDW or DW and finishing after the DW displays, increased from 6 to 12 percent. A majority of pedestrians indicated that they understood the meaning of the countdown signals.

Study data from San Francisco (4) indicate that the number of pedestrians clearing the intersection after the FDW phase decreased significantly after countdown installation. It should be noted that the higher incidence of successful crossings is mostly attributed to pedestrians quickening their pace in response to the countdown display. The study reports a slight decrease in the incidence of pedestrians entering the intersection on the FDW from the before to the after installation periods, as well as decreases in pedestrian/vehicle conflicts and erratic pedestrian behavior in the crosswalk. Additionally, the report identifies a decrease in pedestrians' understanding that starting to cross during the FDW phase is a violation. Interestingly, although 92 percent of pedestrians said that countdown signals are "more helpful" than conventional signals, the proportion of pedestrians who properly interpret the FDW display decreased from 40 percent before to 17 percent after the implementation of the countdown signal. It was also noted in the study findings that "pedestrians are using the countdown signals to decide when to start to cross," but that the presence of the countdown signal did not affect the likelihood of a pedestrian leaving the curb during the FDW. Pedestrians in San Francisco stated that they found the signal to be helpful because it showed the time remaining to cross, but the data do not indicate a significant change in lawful crosswalk entry as a result of the countdown device. Additionally, the report states that the positive impacts on pedestrians' behavior, particularly that they are not more likely to leave the curb during the FDW interval, are more significant than pedestrians' misinterpretation of the FDW display.

Similar findings in Quebec indicate that the presence of countdown devices reduced pedestrian/traffic conflicts significantly, though the actual significance of the reduction is unclear because specific data supporting this conclusion was not included in the report (8). Research was also conducted in the City of Monterey (6) on pedestrian behavior, but only during the after situation, which does not allow for a comparative analysis. Surveys from the Monterey study indicated that most pedestrians understood the meaning of the signal, and researchers suggest that pedestrians who do not understand the signal can "at least...rely on the time indicated on the countdown to dictate their behavior."

One study conducted in the City of Saint-Laurent in Quebec, Canada, surveyed over 4000 pedestrians and found that 80 percent of pedestrians did not understand the FDW display. Follow-up research showed that the presence of countdown signal heads did not increase their understanding. In another study of eight intersections in six Quebec municipalities, a yellow-silhouetted figure phase was added between the white-silhouetted figure phase (signifying "WALK") and a red-silhouetted figure phase (signifying "DON'T WALK") to indicate an interim message, "DON'T BEGIN TO WALK." This study concluded that pedestrians better understood the message of the tri-colored signal head; however, the incidence of compliance did not increase. Another study in Toulouse, France, found no significant change in pedestrian behavior following installation of countdown displays (3).

Research prepared for the Federal Highway Administration (1) indicates that pedestrian countdown signals had a greater negative than positive impact on pedestrian safety in test sites in Sacramento County, California. They found that the proportion of pedestrians who complied with the WALK phase decreased from 82 percent to 68 percent, and the proportion finishing after time ran out increased from 11 percent to 17 percent. They also stated that the signal might be inducing pedestrians to enter the crossing on the FDW. The same study concludes that the percentage of pedestrians conflicting with oncoming traffic increased significantly, that pedestrian countdown signals need further testing to ascertain their effects, and that alternatives other than countdown signals can be more effective in improving pedestrian safety.

From the above discussion, it appears that the countdown signals may cause pedestrians to enter the crosswalk during the FDW interval. In most cases, there was an indication that the signal may aid the pedestrians in exiting the crosswalk before the DW interval. However, it is notable that in some of the studies that emphasized this positive aspect, the proportion of pedestrians entering the crosswalk inappropriately was not studied. Moreover, in two of these studies, specific mention was made of the fact that the device was not intended to stop the pedestrians from entering the crosswalk during the FDW interval. In the case of the San Francisco study, researchers state that the study alerted them to the potentially-significant incidence of improper interpretation of the signals by pedestrians, but the report also states that entry on FDW is not the City's "official policy" and that the behavioral changes observed after the installation were of sufficient merit to outweigh the lack of pedestrian understanding of the FDW display. The statement that San Francisco does not accept entry on the FDW as official policy does not, of course, prevent the pedestrians from entering the intersection on the FDW.

In several surveys, pedestrians responded that the meaning of the countdown was clear to them, yet data gathered indicate that the countdown display has made the FDW interval increasingly unclear. The implication here is that pedestrians show a high degree of confidence that their erroneous interpretations are accurate. Because of this conflict, pedestrian statements regarding the clarity of countdown signals should not necessarily be taken to mean that the installation of the signal is beneficial. It may just mean that they understand that the signal shows the time remaining, but not that they are meant to wait if a countdown is displayed.

BASIC APPROACH TO THE EVALUATION

The San Jose evaluation focused on gaining an understanding of the performance of the countdown signal in five categories discussed in the introduction. These five categories of questions are:

- Does the countdown signal aid pedestrians in getting out of the street before they would be exposed to the danger of oncoming motor vehicles?
- Does the countdown signal cause pedestrians to leave the curb during the FDW phase because they think that they have time to complete the crossing before the countdown reaches zero?
- Does the countdown signal reduce erratic behavior of pedestrians, such as running, hesitating or turning around in the crosswalk?
- Does the countdown signal increase the incidence of motorists entering the intersection on yellow or red?
- Does the countdown signal increase safety?

The performance of the signal was assessed by conducting operations studies, pedestrian surveys, conflict analysis and the review of crash data. Where appropriate, studies were conducted before the installation of the new signal as well as after. The before studies commenced in March 2001 and continued through May 2001. The after studies took place during the period September 2001 through March 2002. The countdown signals were installed at the following intersections (dates of installation are shown in parentheses):

- Market Street & St. John Street (6/12/2001)
- Eleventh Street & San Antonio Street (7/13/2001)
- Santa Clara Street & Twenty-first Street (9/6/2001)
- Market Street & San Carlos Street (9/5/2001)
- Convention Center & San Carlos Street (9/5/2001) (pedestrian crossing)

After the initial "before" studies, it was decided that the intersection of Eleventh and San Antonio would be omitted, because pedestrian volumes were low. It was decided to use the available resources to gather more data at other test sites. For a part of the study, comparative sites, without the countdown signals, were utilized. These sites were the intersections at Almaden Boulevard & San Carlos Street and at Market & Santa Clara Streets.

Overviews of the study methods are presented in the following sections.

Operations Studies

The operations studies consisted of assessing pedestrian compliance, pedestrian walking speeds and motorist behavior.

The overall goal of the pedestrian compliance study was to assess the incidence of non-compliance to the pedestrian signal and unusual or "erratic" pedestrian movements. The objective of the first part of the pedestrian compliance study was to assess the proportion of pedestrians arriving during the DW or FDW displays that waited for the WALK signal before crossing the street. During the second part of the compliance study the proportions of all pedestrians that entered the crosswalk during the WALK, FDW and DW intervals were measured. The third part of this study was aimed at measuring the performance of the signal in getting the pedestrians safely out of the crosswalk. To this end, the numbers of pedestrians exiting the crosswalk on the WALK, FDW and DW were observed. In the last part of the compliance study, the proportions of pedestrians running, stopping/hesitating or turning-around were measured. In addition, the proportion of pedestrians involved in a conflict with a vehicle was also measured.

Pedestrian walking speeds were measured at the study sites to determine whether, on the average, pedestrians could be encouraged by the new signal to enter the crosswalk on the FDW and be rushed to complete their crossing by changes in their behavior. The proportions of motorists entering the intersection on yellow or red were monitored to determine whether the new signal increased the number of motorists entering on yellow or red.

All of the above studies were conducted for the before and after installation situations.

Pedestrian Surveys

The principal objective of the pedestrian surveys was to gain further understanding of the public's interpretation of the countdown signal.

The pedestrians were asked to estimate the time it would take to cross a street. The intent here was to determine whether pedestrians could correctly estimate the time that it takes to cross a particular street. This survey was administered at locations without the countdown device. If they did underestimate the time to cross, this would imply a negative effect of the countdown signal in that it may cause pedestrians to enter the crosswalk during the FDW display and into a situation where they could potentially have insufficient time to cross.

The question was also posed as to whether it was permitted to enter on the FDW, at locations with and without the new signals. The question was also posed in a slightly different way at the locations with countdown signals to get a more direct interpretation of the meaning of the countdown itself.

Safety Studies

An analysis of crashes involving pedestrians was conducted at the study sites, for approximately three years before installation of the countdown signals, and approximately four months after the signals were installed. Since there were too few such crashes to make a statistical comparison of crash characteristics between the before and after periods, the crash reports were read to gain insight as to whether misinterpretation of the FDW display was responsible for the crashes.

A conflict study was carried out before and after installation to establish any differences in conflict occurrence between the before and after period. All studies and surveys were first tested in the field, and then modified based on this experience. Vehicle and pedestrian volume counts were conducted where and when appropriate.

THE STUDY SITES

Sketches, showing pertinent site characteristics are presented in Figures 1 through 6. Other relevant information is provided below for the four principal study sites (those with countdown signals) as well as for the two supplemental sites (those without countdown signals).

The Principal Study Sites – With Countdown Signals

Market Street & San Carlos Street

Located in downtown San Jose, this intersection is adjacent to the McEnery Convention Center, the San Jose Civic Auditorium, and Plaza De Cesar Chavez Park. During conventions, high pedestrian volumes often include many tourists. The Valley Transportation Authority (VTA) light rail travels through this intersection along San Carlos Street. This is a nine-phase traffic signal (seven vehicle phases and two light-rail phases), with pedestrian push buttons for all four pedestrian phases, and is not coordinated with other signals. The pedestrian phases are timed as follows:

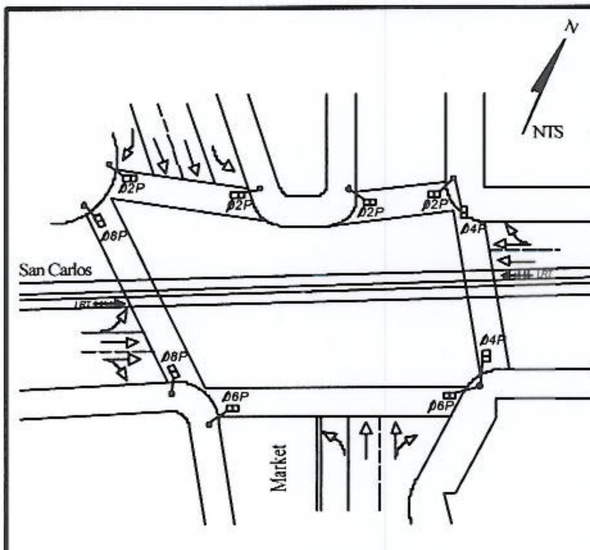


Figure 1. Market & San Carlos

Pedestrian ϕ2 (North-leg crosswalk) has a 9-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 1.5-second "All Red" interval.

Pedestrian ϕ4 (East-leg crosswalk) has a 9-second WALK interval and a 22-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ6 (South-leg crosswalk) has a 9-second WALK interval and a 31-second FDW interval, followed by a 3-second "Yellow" interval, and a 1.5-second "All Red" interval.

Pedestrian ϕ8 (West-leg crosswalk) has a 9-second WALK interval and a 28-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Market Street & St. John Street

Located in downtown San Jose, this intersection is adjacent to the San Jose Post Office, parking structures, and office buildings. This is a two-phase traffic signal with left-turn pockets on all four legs, and pedestrian push buttons for both pedestrian phases. This traffic signal is coordinated with other signals along Market Street, so the WALK interval for the corresponding pedestrian phase will vary. The pedestrian phases are timed as follows:

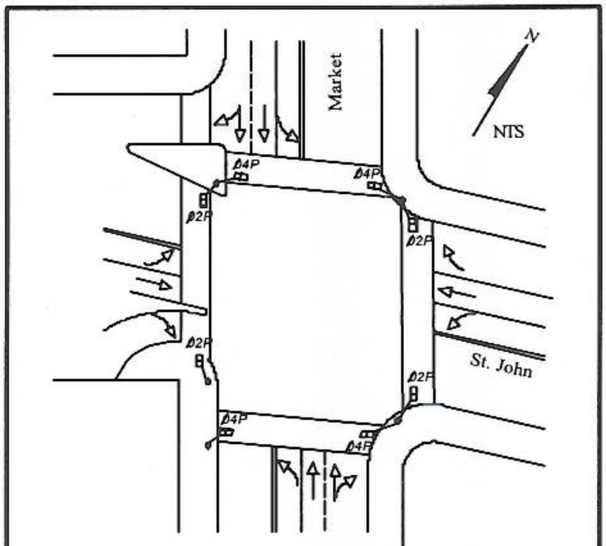


Figure 2. Market & St. John

Pedestrian ϕ2 (East-leg and West-leg crosswalks) has a minimum 5-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ4 (North-leg and South-leg crosswalks) has a 5-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

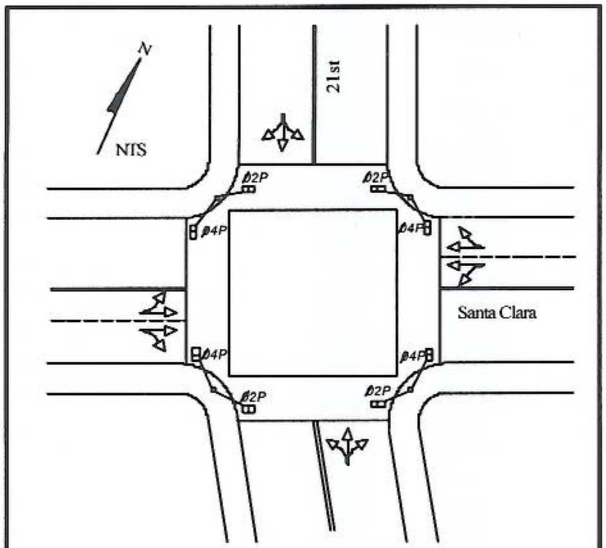


Figure 3. Santa Clara & 21st

Santa Clara Street & Twenty-first Street

Located just east of downtown San Jose, this intersection is near San Jose Academy High School, and lies within both a residential (to the North and South) and commercial (to the East and West) area. This is a two-phase traffic signal with no left-turn pockets, although left-turn movements are permitted from all approaches. There is no vehicle detection system, and no pedestrian push buttons. This traffic signal is coordinated with other signals along Santa Clara Street, so the WALK interval for the corresponding pedestrian phase will vary. The pedestrian phases are timed as follows:

Pedestrian ϕ2 (North-leg and South-leg crosswalks) has a minimum 5-second WALK interval and a 14-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ4 (East-leg and West-leg crosswalks) has a 5-second WALK interval and a 12-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

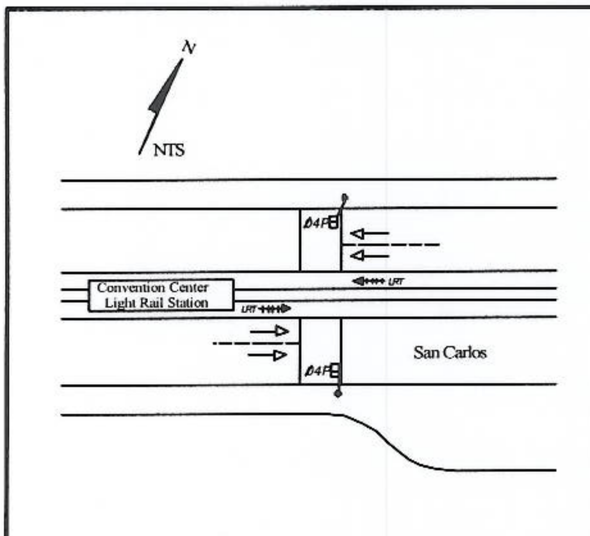


Figure 4. Convention Center & San Carlos

Convention Center & San Carlos Street

This is a mid-block signalized pedestrian crossing located in downtown San Jose on San Carlos Street between Market Street and

Almaden Boulevard. The crosswalk extends from the San Jose Civic Auditorium (on the north side of San Carlos) to the McEnery Convention Center and the main branch of the San Jose Public Library on the south. During conventions, high pedestrian volumes often include many tourists. The VTA light rail travels along San Carlos through this pedestrian crossing, with a light rail station located just west of the crosswalk. This is a four-phase traffic signal that utilizes pedestrian push buttons.

Pedestrian $\phi 4$ has an 8-second WALK interval and a 26-second FDW interval, followed by a 3-second "All Red" interval.

Supplemental Sites – Without Countdown Signals

Almaden Boulevard & San Carlos Street

Located in downtown San Jose, this intersection is adjacent to the Center for the Performing Arts, the San Jose Civic Auditorium, the Hilton & Towers Hotel, and a public parking lot. During events at the city facilities located at and near this intersection, there are high pedestrian volumes, including many tourists. The VTA light rail travels through this intersection along San Carlos Street. This traffic signal utilizes conventional pedestrian signals (without countdown) and was selected for pedestrian surveys at a non-countdown signal location due to it's similar geometric, geographic, and traffic signal design and timing characteristics with Market Street & San Carlos Street. This is a ten-phase traffic signal (eight vehicle phases and two light-rail phases), with pedestrian push buttons for all four pedestrian phases, and is not coordinated with other signals. The pedestrian phases are timed as follows:

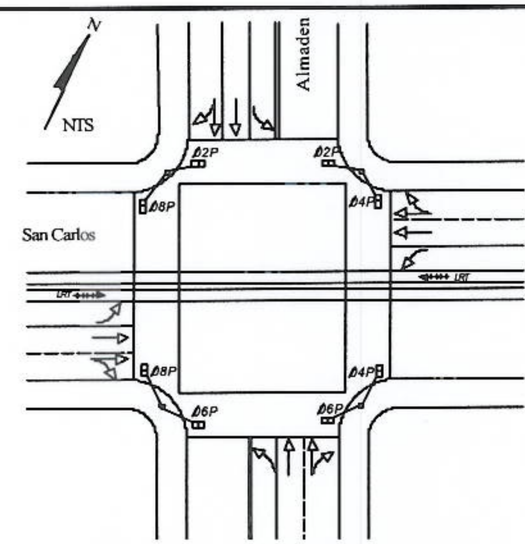


Figure 5. Almaden & San Carlos

Pedestrian ϕ2 (North-leg crosswalk) has a 9-second WALK interval and a 30-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ4 (East-leg crosswalk) has a 9-second WALK interval and a 28-second FDW interval, followed by a 3.5-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ6 (South-leg crosswalk) has a 9-second WALK interval and a 33-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ8 (West-leg crosswalk) has a 9-second FDW interval and a 27-second FDW interval, followed by a 3.5-second "Yellow" interval, and a 1-second "All Red" interval.

Market Street & Santa Clara Street

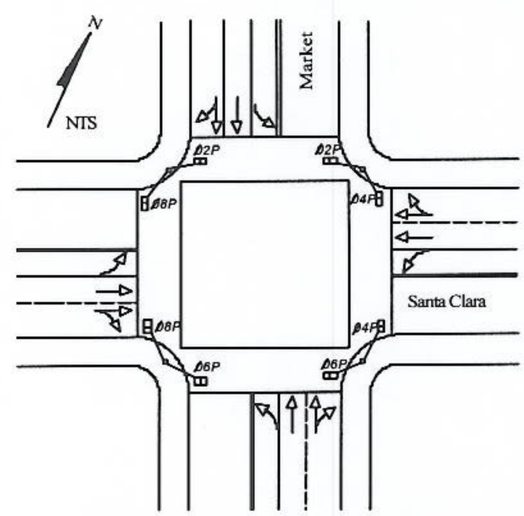


Figure 6. Market & Santa Clara

Located in downtown San Jose, this intersection is adjacent to office buildings and near a variety of downtown business establishments. This traffic signal utilizes conventional pedestrian signals (without countdown) and was selected for pedestrian surveys at a non-countdown signal location due to it's similar geometric, geographic, and traffic signal timing characteristics with Market Street & St. John Street. This is a six-phase traffic signal with protected left-turns on Market Street, left-turn pockets on Santa Clara Street, and pedestrian push buttons for all pedestrian phases. This traffic signal is coordinated with other signals along Market Street, so the WALK interval for the corresponding pedestrian phase will vary. The pedestrian phases are timed as follows:

Pedestrian $\phi 2$ (North-leg crosswalk) has a 5-second WALK interval and an 18-second FDW interval, followed by a 3-second "Yellow" interval, and a 2-second "All Red" interval.

Pedestrian $\phi 4$ (East-leg crosswalk) has a minimum 5-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 2-second "All Red" interval.
Pedestrian $\phi 6$ (South-leg crosswalk) has a 5-second WALK interval and a 18-second FDW interval, followed by a 3-second "Yellow" interval, and a 2-second "All Red" interval.

Pedestrian $\phi 8$ (West-leg crosswalk) has a minimum 5-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 2-second "All Red" interval.

PEDESTRIAN BEHAVIOR

Pedestrian Compliance

Details of the study methods and instructions are provided in Volume 2, Appendix A, together with specific results. Pedestrian volume counts are contained in Volume 2, Appendix B.

Peak times for pedestrian and vehicle volumes were chosen for observations and data collection. For the San Carlos sites, the schedule of conventions at the nearby center was also taken into account. The expectation was that conference participants would provide study subjects that would not be regular users.

Proportion Waiting for the WALK

This part of the pedestrian compliance study consisted of assessing the proportion of pedestrians that arrived during the FDW display and waited for the WALK signal. The intent was to get some indication as to whether the countdown signal would cause those pedestrians arriving during the FDW to enter the crosswalk during the same phase.

The results are presented in Table 1. The percentages are based on the total number of pedestrians that arrived at the crosswalk during the FDW display (those that entered plus those that waited for the next WALK interval). The percentages of pedestrians that arrived during the FDW interval and waited for the next WALK interval decreased significantly at three of the four intersections (statistically different at the five percent level of significance). This trend was more pronounced for the 21st/Santa Clara and Market/St. John intersections. The pedestrians at these intersections are more likely to be regular users and may have become familiar with the countdown signals. It should be noted that the number of pedestrians waiting on the FDW is relatively small compared to the total number entering.

Table 1. Pedestrian Compliance Summary -- Waiting To Cross

Location	Number of pedestrians arriving at crosswalk during the FDW display		% of pedestrians (arriving during FDW) that waited for WALK display		
	Before	After	Before	After	Difference
Market & San Carlos	296	279	14.9%	8.6%	-6.3%
Santa Clara & 21st	106	210	18.9%	2.9%	-16.0%
Convention Ctr & San Carlos	69	151	11.6%	11.9%	0.3%
Market & St. John	79	220	41.8%	9.1%	-32.7%

From the above discussion, it may be concluded that the countdown signal may be causing people to enter the intersection on the FDW (perhaps when the countdown still displays a high number that causes the pedestrians to believe that they can still safely cross the intersection).

Proportion Entering Crosswalk During the WALK, FDW & DW Displays

The total numbers of pedestrians entering selected crosswalks on the WALK, FDW and the DW displays, respectively, were recorded. The results are summarized in Table 2. The proportion of entries on FDW increased for all four intersections. On the DW interval, the proportion of entries decreased at three of the intersections. The fact that proportionally more pedestrians entered on the FDW could be construed to mean that the new signal causes them to enter the crosswalk during the FDW displa y. It should be noted though that the differences are relatively small and are not statistically different at the five percent level of significance.

Table 2. Pedestrian Compliance Summary – Entering Crosswalk

Location	Number of Pedestrians Observed		% of Pedestrians Entering on WALK			% of Pedestrians Entering on FDW			% of Pedestrians Entering on DW		
	Before	After	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Market & San Carlos	2038	1695	78.7%	76.3%	-2.4%	12.4%	15.0%	2.7%	8.9%	8.6%	-0.3%
Santa Clara & 21st	482	1113	72.6%	73.4%	0.8%	17.8%	18.3%	0.5%	9.5%	8.3%	-1.3%
Conv Ctr & San Carlos	464	933	49.8%	49.9%	0.2%	13.1%	14.3%	1.1%	37.1%	35.8%	-1.3%
Market & St. John	406	1599	82.3%	79.4%	-2.9%	11.3%	12.5%	1.2%	6.4%	8.1%	1.7%

Proportion Exiting Crosswalk During the WALK, FDW & DW Displays

The numbers of pedestrians exiting the crosswalk on the WALK, FDW and DW were observed; Table 3 contains a summary of the results.

Table 3. Pedestrian Compliance Summary -- Exiting Crosswalk

Location	Number of Pedestrians Observed		% of Pedestrians Exiting on WALK			% of Pedestrians Exiting on FDW			% of Pedestrians Exiting on DW		
	Before	After	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Market & San Carlos	1993	1673	0.7%	0.9%	0.2%	86.0%	87.9%	2.0%	13.4%	11.2%	-2.2%
Santa Clara & 21st	484	1101	33.9%	30.2%	-3.7%	48.3%	55.9%	7.6%	17.8%	13.9%	-3.9%
Conv Ctr & San Carlos	463	909	7.8%	5.1%	-2.7%	62.0%	69.1%	7.1%	30.2%	25.9%	-4.4%
Market & St. John	406	1586	28.1%	23.3%	-4.8%	59.6%	67.5%	7.9%	12.3%	9.3%	-3.0%

The proportion of pedestrians exiting during the FDW indication increased at all of the sites, while the proportions exiting on the DW decreased. All increases were statistically different at the five percent level of significance. This may be an indication that pedestrians are changing their walking behavior and that they use the countdown as an indication of the need to increase their walking speed. From this viewpoint, the signal may be viewed as beneficial.

Unusual Behavior

The numbers of pedestrians running, stopping/hesitating or turning-around were recorded as well as the number of pedestrians involved in a conflict with a vehicle. A conflict was defined as any action by a vehicle that caused a change in the behavior of a pedestrian. The results are summarized in Tables 4 and 5.

The differences between the before and after results are relatively small and do not show a pattern. Moreover, since judgment was involved and different observers participated, the results may also be inconsistent.

Table 4. Pedestrian Compliance Summary -- Pedestrian Action

Location	Number of Pedestrians Observed		% of Pedestrians that Ran while Crossing			% of Pedestrians that Stopped/ Hesitated			% of Pedestrians that Turned Around/ Returned to Curb		
	Before	After	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Market & San Carlos	2038	1695	3.6%	2.8%	-0.9%	1.1%	2.8%	1.6%	0.1%	0.1%	0.0%
Santa Clara & 21st	482	1113	2.3%	3.3%	1.0%	0.6%	0.8%	0.2%	0.4%	0.0%	-0.4%
Conv Ctr & San Carlos	464	933	5.4%	2.7%	-2.7%	5.2%	6.5%	1.4%	0.6%	0.1%	-0.5%
Market & St. John	406	1599	4.9%	2.7%	-2.2%	1.5%	0.6%	-0.9%	0.2%	0.1%	-0.1%

Table 5. Pedestrian Compliance Summary -- Conflicts

Location	Number of Pedestrians Observed		% of Pedestrians Delayed due to a Vehicle Conflict			% of Pedestrians Hurried due to a Vehicle Conflict		
	Before	After	Before	After	Difference	Before	After	Difference
Market & San Carlos	2038	1695	1.6%	2.4%	0.7%	1.1%	0.5%	-0.5%
Santa Clara & 21st	482	1113	0.6%	0.7%	0.1%	0.2%	0.6%	0.4%
Conv Ctr & San Carlos	464	933	5.0%	0.2%	-4.7%	0.0%	0.0%	0.0%
Market & St. John	406	1599	2.0%	0.4%	-1.6%	1.2%	0.3%	-1.0%

Pedestrian Walking Speeds

The details of the study procedure and results are presented in Volume 2, Appendix C.

Field studies were carried out to assess actual pedestrian crossing times at several intersections. Data were gathered at signalized intersections before the devices were installed and then again at the same intersections after countdown signals were placed. Pedestrians entering a crosswalk were observed, and their curb-to-curb time was recorded.

The data gathered in this portion of the study were collected to determine if, and to what extent, the presence of the countdown signal impacts pedestrian crossing speeds. The results are summarized in Table 6. Figures 7 and 8 illustrate the pedestrian movement codes referred to in Table 6.

Table 6. Walking Speeds Summary (Selected Intersections)

Location	Pedestrian Movement (see figures 7 and 8)	Before				After				Difference in Average Speed, ft/s
		No. of Samples	Distance, ft	Average Speed, ft/s	Standard Deviation	No. of Samples	Distance, ft	Average Speed, ft/s	Standard Deviation	
Market & St. John	A, B	9	98	6.7	1.07	3	98	6.9	0.58	0.1
	C, D	4	93	5.8	0.52	8	93	5.7	1.02	-0.1
	E, F	24	88	5.7	1.43	71	88	5.8	1.15	0.1
	G, H	15	84	5.8	1.62	0	84	n/a	n/a	n/a
	Summary	52	n/a	5.9	1.41	82	n/a	5.8	1.14	-0.1
Santa Clara & 21st	A, B	86	38	4.3	0.70	52	38	4.9	1.06	0.6
	C, D	13	45	4.2	0.96	17	45	3.6	0.73	-0.6
	G, H	17	38	3.8	0.88	20	38	3.8	0.52	0.0
	G, H	63	45	3.7	0.98	64	45	4.1	1.44	0.4
	Summary	179	n/a	4.0	0.88	153	n/a	4.3	1.24	0.2
Conv Ctr & San Carlos	C	86	100	4.6	0.82	61	100	4.4	1.34	-0.2
	C1	42	25	3.5	0.62	19	25	3.2	0.90	-0.4
	C2	53	33	4.7	1.23	7	33	4.2	1.00	-0.5
	D	5	100	6.6	1.78	9	100	4.4	1.00	-2.2
	D1	3	33	3.9	0.87	1	33	3.0	n/a	-0.9
	D2	6	25	3.4	0.76	7	25	3.2	1.28	-0.2
	Summary	195	n/a	4.4	1.11	104	n/a	4.1	1.29	-0.3

Figure 7. Movement Codes (Standard Intersections)

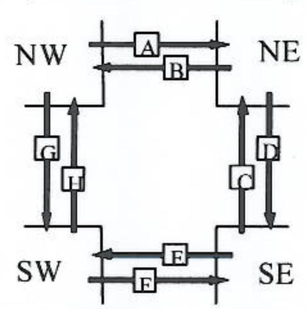
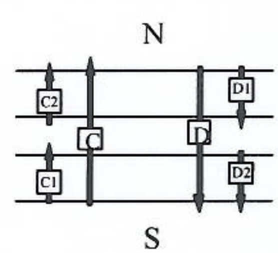


Figure 8. Movement Codes (Convention Center & San Carlos)



Data from this portion of the study indicate that pedestrians' crossing speeds are negligibly affected by the presence of the countdown signal. It is notable that the differences in walking speeds are much greater when the walking speeds for the different sites are compared. This reinforces the conclusion that the countdown does not significantly affect walking speeds.

Pedestrian Surveys

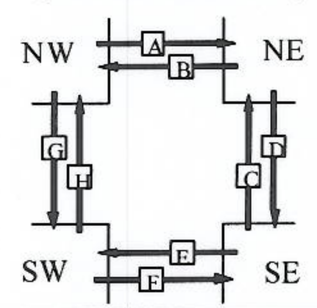
Four short surveys were designed to gather data on pedestrians' interpretations of various intersection features. Pedestrians were selected at random from those who were approaching the curb to cross at an intersectio n. The specific instructions, survey forms, and details of the results are presented in Volume 2, Appendix D.

Survey 1: Perception of Crossing Time / Frequency of Crosswalk Use

The purpose of this survey was to determine whether pedestrians could accurately estimate the time necessary to traverse an intersection. This survey was conducted at two separate intersections where no countdown signal was present. The reason for using intersections without countdown signals for data collection was to eliminate bias from people knowing the design clearance time, which they would have been able to see at intersections with a countdown device. Data were collected at Market & Santa Clara Streets, and also at the intersection of Almaden Avenue & San Carlos Street. The observations were made when large numbers of pedestrians were expected such as during convention center events.

Pedestrians were asked how many seconds they thought it would take to cross these intersections and also how often they used the intersection (daily, weekly, monthly, or just that day).
A summary of the results is shown in Tables 7 and 8. The adjusted standard deviation was measured, where applicable, by discarding the outliners, which were two or more times larger than the next highest response.

Figure 7. Movement Codes (Standard Intersections)



The perceived average crossing times for the crosswalks range from about three to ten seconds below the design clearance time. Additionally, the intersection width for movements B and F (see Figure 7) are similar, as are widths for movements D and H; however, average perceived times for B and F turned out to be dissimilar, as did average times for D and H. The results indicate that pedestrians do not have a good sense of the time necessary to traverse an intersection. Also, a wide range of responses was received, but the standard deviation is reasonably small. The latter result probably stems from the fact that 64 percent of the pedestrians are daily users.

Table 7. Pedestrian Perception Of Crossing Time

Location	Pedestrian Movement (see fig. 7)	Pedestrian Clearance Time (seconds)	Number of Responses	Average	Standard Deviation	Adjusted Average	Adjusted Standard Deviation	Adjusted Range (seconds)
Market & Santa Clara	B	18	12	18.67	14.83	13.67	7.51	5~30
	D	19	21	20.48	27.53	9.05	4.57	5~20
	F	18	8	11.88	7.88	11.88	7.88	5~30
	H	19	11	15.45	7.15	15.45	7.15	5~30
Almaden & San Carlos	C	28	14	13.36	5.75	13.36	5.75	5~25
	E	33	6	20.33	8.36	20.33	8.36	9~35

Table 8. Frequency Of Crosswalk Use Corresponding To Perception Of Crossing Time

Location	Movement (see fig. 7)	Frequency of Crosswalk Use				
		No. of Responses	Daily	Weekly	Monthly	Just Today
Market & Santa Clara	B	12	8	1	1	2
	D	21	19	2	0	0
	F	8	8	0	0	0
	H	11	11	0	0	0
	Summary	52 (100%)	46 (88%)	3 (6%)	1 (2%)	2 (4%)
Almaden & San Carlos	C	14	0	2	3	9
	E	6	0	0	1	5
	Summary	20 (100%)	0 (0%)	2 (10%)	4 (20%)	14 (70%)
Overall Summary	**All**	**72 (100%)**	**46 (64%)**	**5 (7%)**	**5 (7%)**	**16 (22%)**

Overall, it may be concluded that pedestrians do not have a reasonably good sense of clearance time, and they may be unable to distinguish clearly between the time required for wider streets and that required for narrower streets.

Survey 2: Understanding of Flashing Hand Display (Without Countdown)

The purpose of this survey was to determine whether pedestrians understand the message

provided by traditional FDW displays without countdown devices. This survey was conducted at Market & Santa Clara Streets where no countdown signals were present.
Pedestrians were shown a figure of the upraised hand symbol and asked whether or not they believe it is permitted to enter the crosswalk when the symbol is flashing.

A summary of the results is shown in Table 9. Data collected at these intersections indicate that a large majority of pedestrians properly interpret the FDW display (without countdown), i.e., that it is not permitted to enter the intersection on the FDW.

Table 9. Pedestrian Understanding Of Flashing Hand Display (Without Countdown)

Location	Pedestrian Responses		Response Percentages	
	Permitted to Cross	Not Permitted to Cross	Permitted to Cross	Not Permitted to Cross
Market & Santa Clara	13	39	**24%**	**76%**

Survey 3: Understanding of Flashing Hand Display (With Countdown)

The purpose of this survey was to determine whether pedestrians understand the message provided by pedestrian signal displays with countdown devices. This survey, which was conducted at an intersection where a pedestrian countdown signal was present, differs from Survey 2 only in that the question references a signal with a countdown device, rather than without. Data were collected at the intersection of Market & St. John Streets.

Pedestrians were shown a figure of the upraised hand symbol with adjacent countdown display and asked whether or not they believed it is permitted to enter the crosswalk when the symbol is flashing. The results of the survey are summarized in Table 10.

Table 10. Pedestrian Understanding Of Flashing Hand Display (With Countdown)

Location	Pedestrian Responses		Response Percentages	
	Permitted to Cross	Not Permitted to Cross	Permitted to Cross	Not Permitted to Cross
Market & St. John	23	33	**41%**	**59%**

Data collected at this intersection indicate that pedestrians properly interpret the FDW display about 59 percent of the time. It is of interest that, in Survey 2, which was conducted at an intersection with traditional flashing-hand displays, pedestrians properly interpreted the signal 76 percent of the time. These results indicate that the misunderstanding of the conventional FDW display increases with the presence of the countdown display.

Survey 4: Meaning of the Countdown

The objective of this survey was to understand pedestrian perception of the meaning of a countdown display, in the context of whether it signifies that they can enter on the FDW.

The surveyor gestured toward a countdown signal, in the process of counting down, then asked pedestrians about the meaning of the countdown display. They were asked whether they could begin crossing the intersection if they could finish before the timer counted down to zero or if they should instead wait for the next WALK signal. They were also asked the frequency with which they use that particular crosswalk. The results of the survey are summarized in Table 11.

Table 11. Pedestrian Understanding Of Meaning Of The Countdown

Location	Pedestrian Responses		Frequency of Crosswalk Use			
	Walk if Finish Before Zero	Wait for Next WALK Signal	Daily	Weekly	Monthly	Just Today
Market & St. John	24	3	18	3	3	3
Conv Ctr & San Carlos	21	8	9	17	1	2
Total	**45 (80%)**	11 (20%)	**27 (48%)**	**20 (36%)**	**4 (7%)**	5 (9%)

Data collected at this intersection indicate that most pedestrians improperly interpret the countdown display. Eighty percent of the respondents said that they could begin the crossing if they thought they could finish before it counted down to zero. This would indicate that the intended meaning of this type of signal is widely misunderstood and that the signal may cause pedestrians to enter the intersection during the FDW.

MOTORIST BEHAVIOR

The numbers of motorists entering the intersection on yellow or red were monitored to determine whether the presence of the new signal increased the proportion of motorists entering on yellow or red. Both the associated direction (in the same direction as the FDW and or countdown display) and the opposing direction (crossing the associated direction) were observed. However, observation of the opposing direction was abandoned soon after the study commenced, because the number of violations was insignificant. Volume 2, Appendix E contains the details of the study procedures and results. Vehicle volume counts were conducted at the same time. The counts are presented in Volume 2, Appendix B.

The results for entries on the yellow are shown in Table 12, for red in Table 13, and for yellow and red combined in Table 14. In all three tables it can be seen that the proportion of violations decreased after the countdown signals were installed. Since the differences are small and there would not appear to be a logical explanation for the decrease, it may be concluded that there was no discernable negative effect from the installation of the signal.

Table 12. Motorist Behavior -- Entering Intersection During Yellow

Location	Total Number of Vehicles Entering Intersection (during period observed)		% of Vehicles Entering Intersection During Yellow Indication		
	Before	After	Before	After	Difference
Market & San Carlos	7339	22162	2.2%	0.7%	-1.5%
Santa Clara & 21st	5269	13246	0.9%	1.9%	1.0%
Market & St. John	3243	14741	1.1%	0.6%	-0.5%

Table 13. Motorist Behavior -- Entering Intersection During Red

Location	Total Number of Vehicles Entering Intersection (during period observed)		% of Vehicles Entering Intersection During Red Indication (excluding permitted right-turns on Red)		
	Before	After	Before	After	Difference
Market & San Carlos	7339	22162	0.3%	0.2%	-0.1%
Santa Clara & 21st	5269	13246	0.6%	0.5%	-0.1%
Market & St. John	3243	14741	0.2%	0.1%	-0.1%

Table 14. Motorist Behavior -- Entering Intersection During Yellow Or Red

Location	Total Number of Vehicles Entering Intersection (during period observed)		% of Vehicles Entering Intersection During Yellow or Red (excluding permitted right-turns on Red)		
	Before	After	Before	After	Difference
Market & San Carlos	7339	22162	2.5%	0.9%	-1.6%
Santa Clara & 21st	5269	13246	1.5%	2.4%	0.9%
Market & St. John	3243	14741	1.4%	0.7%	-0.6%

TRAFFIC CONFLICT AND CRASH ANALYSIS

Crash Analysis

An analysis of crashes involving pedestrians and bicyclists was carried out at the intersections where the countdown signal was installed, for a period of three years before the installation and for periods varying from four to seven months after the installation. The primary purpose was to determine whether the countdown signal resulted in any difference in the crash occurrences at the intersections.

The crash reports were reviewed to determine whether a misinterpretation of the FDW display played a role in crash patterns. A total of 24 crash reports were reviewed for the before period. No reported crashes occurred during the after installation period. No evidence was found that misinterpretation of the FDW played a role in any of the crashes.

Traffic Conflicts

Pedestrian-vehicle conflicts were recorded to gain some additional perspective on the safety performance of the intersections during both the before and after installation situations. For the purpose of this portion of the study, a conflict was defined as an event when either a pedestrian or a vehicle was delayed as a result of an unlawful action by a pedestrian or a vehicle. Conflicts were recorded during the before and after periods for selected crosswalks and intersections. Volume 2, Appendix F contains the details of the study procedures and results.

The results are summarized in Tables 15 through 18. Relatively few conflicts were observed and it can be concluded that the differences between the before and after installation conflict rates are relatively small. However, there are a few movements (see Tables 15 and 16) where the differences are more pronounced and indicate that the countdown signal may have a beneficial effect, i.e. the conflict rate is reduced in the after installation period. It should be noted, however that the collection of these data requires judgment on the collector's part. Since several people collected data, there may be some bias in the results.

Table 15. Traffic Conflicts Summary – Vehicles Approaching From The West

Location	Right Turn			Left Turn			Straight Near			Straight Far		
	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Number of Conflicts												
Market & San Carlos	48	19		2	n/a		1	4		0	1	
Santa Clara & 21st	1	0		0	0		3	1		0	0	
Conv Ctr & San Carlos	n/a	n/a		n/a	n/a		5	6		n/a	n/a	
Market & St. John	7	9		2	5		0	0		0	0	
Number of Conflicts per Hour												
Market & San Carlos	6.0	1.9	-4.1	0.3	n/a	n/a	0.1	0.4	0.3	0.0	0.1	0.1
Santa Clara & 21st	0.3	0.0	-0.3	0.0	0.0	0.0	0.8	0.2	-0.6	0.0	0.0	0.0
Conv Ctr & San Carlos	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.5	-0.5	0.0	0.0	0.0
Market & St. John	4.7	1.1	-3.5	1.3	0.6	-0.7	0.0	0.0	0.0	0.0	0.0	0.0

Table 16. Traffic Conflicts Summary – Vehicles Approaching From The East

Location	Right Turn			Left Turn			Straight Near			Straight Far		
	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Number of Conflicts												
Market & San Carlos	4	n/a		0	n/a		0	n/a		0	n/a	
Santa Clara & 21st	2	1		1	0		0	1		0	2	
Conv Ctr & San Carlos	n/a	n/a		n/a	n/a		9	0		n/a	n/a	
Market & St. John	0	3		17	28		1	0		0	1	
Number of Conflicts per Hour												
Market & San Carlos	0.7	n/a	n/a	0.0	n/a	n/a	0.0	n/a	n/a	0.0	n/a	n/a
Santa Clara & 21st	0.5	0.2	-0.3	0.3	0.0	-0.3	0.0	0.2	0.2	0.0	0.3	0.3
Conv Ctr & San Carlos	n/a	n/a	n/a	n/a	n/a	n/a	3.6	0.0	-3.6	n/a	n/a	n/a
Market & St. John	0.0	0.4	0.4	11.3	3.5	-7.8	0.7	0.0	-0.7	0.0	0.1	0.1

Table 17. Traffic Conflicts Summary – Vehicles Approaching From The North

Location	Right Turn			Left Turn			Straight Near			Straight Far		
	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Number of Conflicts												
Market & San Carlos	12	19		3	1		1	18		1	2	
Santa Clara & 21st	0	2		3	7		1	2		1	0	
Conv Ctr & San Carlos	n/a	n/a		n/a	n/a		n/a	n/a		n/a	n/a	
Market & St. John	0	0		2	3		0	1		0	5	
Number of Conflicts per Hour												
Market & San Carlos	1.5	1.9	0.4	0.4	0.1	-0.3	0.1	1.8	1.7	0.1	0.2	0.1
Santa Clara & 21st	0.0	0.3	0.3	0.8	1.2	0.4	0.3	0.3	0.1	0.3	0.0	-0.3
Conv Ctr & San Carlos	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Market & St. John	0.0	0.0	0.0	1.3	0.4	-1.0	0.0	0.1	0.1	0.0	0.6	0.6

Table 18. Traffic Conflicts Summary – Vehicles Approaching From The South

Location	Right Turn			Left Turn			Straight Near			Straight Far		
	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Number of Conflicts												
Market & San Carlos	5	n/a		6	5		4	n/a		1	n/a	
Santa Clara & 21st	2	2		4	3		3	0		0	0	
Conv Ctr & San Carlos	n/a	n/a		n/a	n/a		n/a	n/a		n/a	n/a	
Market & St. John	1	2		0	1		0	5		0	1	
Number of Conflicts per Hour												
Market & San Carlos	0.8	n/a	n/a	0.8	0.5	-0.3	0.7	n/a	n/a	0.2	n/a	n/a
Santa Clara & 21st	0.5	0.3	-0.2	1.0	0.5	-0.5	0.8	0.0	-0.8	0.0	0.0	0.0
Conv Ctr & San Carlos	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Market & St. John	0.7	0.3	-0.4	0.0	0.1	0.1	0.0	0.6	0.6	0.0	0.1	0.1

PRACTICE FOR PEDESTRIAN SIGNAL TIMING IN CALIFORNIA

Practices for calculating the pedestrian clearance interval, and timing the FDW interval, vary among California jurisdictions. The distance pedestrians travel to cross a street (in feet), divided by four (feet per second), is a generally accepted method of calculating the pedestrian clearance interval. But there is some flexibility in determining the distance across a street, as well as including vehicle yellow time in the pedestrian clearance interval when timing the FDW interval.

Inquiries to several California municipalities illustrate the variations in these practices. Both the City of San Jose and the City of Stockton do not include vehicle yellow time in the pedestrian clearance interval and generally measure the crosswalk from curb to curb when calculating the time of the FDW interval. The City of Berkeley does not include yellow time in the pedestrian clearance interval and generally measures the crosswalk from curb to the middle of the farthest traveled lane. The City of Fountain Valley includes yellow time in the pedestrian clearance interval and generally measures the crosswalk from curb to curb. The City of Oakland includes yellow time in the pedestrian clearance interval and generally measures the crosswalk from curb to curb, subtracting the parking lane width (at far end) and half of the farthest traveled lane. The City of Walnut Creek generally includes yellow time in the pedestrian clearance interval (except at certain intersections such as school and hospital crossings), and crosswalks are measured from curb to the middle of the farthest traveled lane.

These various practices affect the initial time displayed by the countdown signals. For example, a countdown signal accompanying the FDW interval for a crosswalk measuring 80 feet from curb to curb, 68 feet from curb to middle of farthest lane, with a 4 second vehicle yellow time, would begin counting down at 20 (in San Jose and Stockton), at 17 (in Berkeley), at 16 (in Fountain Valley), and at 13 (in Walnut Creek and Oakland). In all of these cases, current pedestrian signal timing guidelines are complied with, although the amount of time pedestrians have to cross once the FDW is displayed would be different depending upon the jurisdiction. However, it should be noted that if the pedestrian were to see 13 seconds on the countdown device in Walnut Creek and San Jose respectively, the remaining time to cross would be the same, notwithstanding the fact that the start time in San Jose would be 20 seconds.

SUMMARY OF MAJOR FINDINGS

The following are major findings identified in the study:

Pedestrian Behavior

- The percentage of pedestrians that arrived during the FDW interval and waited for the walk signal decreased significantly after the countdown signal was introduced. This trend was more pronounced at intersections where there were likely to be more regular users adjusting to the new signals. The countdown signal may be causing people to enter the intersection on the FDW, particularly when the countdown still displays a high number, by making pedestrians feel that they can still safely cross the intersection.
- The proportion of entries on FDW increased for all intersections, but the differences were relatively small. The proportion of pedestrians exiting during the FDW indication increased at all of the sites, while the proportions exiting on the DW decreased. This may be an indication that pedestrians used the information conveyed by the timer to adjust their walking speeds in order to clear the intersection before the DW phase.
- There was little difference in the before-and-after proportions of unusual activity, i.e. of pedestrians running, stopping/hesitating turning-around and pedestrians involved in a conflict with a vehicle. A conflict was defined as any action by a vehicle that caused a change in the behavior of a pedestrian.
- Pedestrians' crossing speeds were negligibly affected by the presence of the countdown signal. The change in average walking speeds from before to the after installation, at individual intersections, is small compared to the variation of walking speeds among different intersections. This leads to the conclusion that other factors have a far greater effect on walking speeds than the countdown signal. Those factors can vary and were not recorded in this report.
- Pedestrians do not have a reasonably good sense of clearance time, and they may be unable to distinguish clearly between the time required for wider streets and that required for narrower streets.

- At locations without a countdown signal, when pedestrians were asked whether it was permitted to enter a crosswalk on the FDW, 76 percent correctly responded "no". When the same question was asked at location with a countdown device, 59 percent correctly responded "no". This disparity in understanding of the signals indicates that the countdown device may result in pedestrians believing that they may enter the intersection during the FDW. When the question was posed in a different way, i.e. whether one was allowed to enter the crosswalk on FDW if the crossing could be completed before the countdown went to zero, 80 percent incorrectly responded "yes". This also indicates that more pedestrians believe it is permitted to enter the crosswalk during the FDW display with a countdown signal.

Motorist Behavior

Observation of motorist signal violations (entering in yellow or red) showed no discernable negative effect from the installation of the signal.

Safety Performance

An analysis of crash reports for a period of approximately three years before the installation of the signal and approximately four to seven months after, showed no evidence that misinterpretation of the FDW or the countdown device played a role in any of the crashes.

The pedestrian-vehicle conflict study, wherein a conflict was defined as an event when either a pedestrian or a vehicle was delayed as a result of an unlawful action by a pedestrian or a vehicle, showed that the differences between the before and after conflict rates (conflicts per hour) are relatively small. There are a few movements where the differences were more pronounced and indicate that the countdown signal may have a beneficial effect, i.e. the conflict rate is reduced in the after period. It should be noted, however that the collection of these data requires judgment on the collector's part. Since several people collected data, there may be some bias in the results.

DISCUSSION OF MAJOR FINDINGS

The studies of pedestrian behavior indicated that the presence of a countdown signal caused more pedestrians to enter the crosswalk on the FDW indication, which may be viewed as negative since it results in an unlawful action. It can also cause some pedestrians to step into the crosswalk and not be able to clear the intersection before being confronted with a conflicting green indication for vehicles. However, there was also an indication that a larger proportion of pedestrians are now completing their crossing on the FDW. This result may be construed as positive, since it would seem that more pedestrians get out of the crosswalk before the DW and are using the additional information provided by the countdown signal to complete their crossings in the time provided. It should be noted, that completing a crossing before the DW reduces the chances for pedestrians to be confronted with conflicting vehicle movements. This reduction appears to be greater than the increased proportion of pedestrians entering the crosswalk during the FDW.

The pedestrian survey results showed that the pedestrians interpreted the meaning of the FDW indication, when used in conjunction with the countdown signal, differently than they interpreted the FDW indication with no accompanying countdown device. Pedestrians appear to believe that it is permitted to cross if they can complete the crossing before the countdown reaches zero. This may be an indication that pedestrians believe the countdown signal provides more information from which to make a decision, thus shifting the importance from the FDW display to the countdown signal.

These conclusions are generally borne out by the results obtained in other studies.

RECOMMENDATIONS

It should be kept in mind that the real benefits of a countdown signal would consist of a reduction in pedestrian-related crashes connected to the new signal. Determining the extent of such benefits would probably be difficult in the short term, since pedestrian-related crashes are relatively rare occurrences and establishing a reliable database would require an extensive effort over several years. It is therefore unlikely that substantially better data will become available soon for decision-making regarding the implementation of the countdown signal. Consequently, the results of current studies will therefore have to suffice. Since there are apparently both advantages and disadvantages to the implementation of the countdown signal in its current form, an appropriate strategy may be to implement the signal but to address the associated problems directly.

Potential solutions could include educating the public on the meaning of the countdown display and modification of the countdown signal to display the initial walk interval (counting down) in green, followed by the pedestrian clearance interval (counting down) in red, without the conventional pedestrian symbols.

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